CHANGING PATTERNS OF CROPLAND USE

IN BIST DOAB, PUNJAB :

1951-1968

GURBACHAN SINGH

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DEDICATION

To my mother P. Kaur and in sweet memory of my father K. Singh (1900-1973)

ABSTRACT

This study considers the changes which have occurred in the agrarian economy of Bist Doab, Punjab (India) during the period 1951-1968, a period coinciding with the first three Five-Year Plans of India. It sets out to map, describe and analyse these changes, to capture emerging patterns and to investigate the processes involved in change. In pursuing these aims, the study tests three hypotheses: that agricultural development is a continuous process of linked stages; that water is the most important catalytic factor in explaining and promoting agricultural development and change; and that the human element is critical in any development process and especially so in agricultural development.

First the problem is identified and the sources, form and nature of data are described. An assessment of the role of the physical, social, economic and human environments, technological advances and other related infra-structure in promoting or hindering change is made. The emerging patterns are described and the changes analysed by using various quantitative and non-quantitative techniques. The statistical techniques included the use of Regression, Correlation and Variance techniques and cluster analysis techniques. Automated cartography has made a significant contribution in mapping most of the information. The processes involved in shaping and producing these changes have been investigated. The incoming of experienced and innovative-minded farmers, irrigation water, consolidation of holdings, HYV package, and new technology have played major roles in the transformation of Punjab agriculture. The changes have been very rapid and numerous. The

explanation for these changes is sought partly in physical, social, economic, political and technical factors, and partly in the responses and initiatives of the people involved. A series of themes is developed and each chapter considers a different aspect of the rural transformation in which development and change could be demonstrated. Specific case studies of farms and villages have also been carried out to investigate various aspects of change and development. Interviews with the farmers and persons connected with development have further helped in illustrating these themes. Changes reflect time sequence which is analysed and discussed. As far as possible, the spatial and regional differences are brought out and effectively explained. The themes taken up in the study are closely interrelated and, when taken together, build up a picture of dynamic change in the rural scene of Bist Doab during the period under review.

The study supports the validity of all the three hypotheses put forth. The principal contribution of this study is firstly towards further understanding of the agricultural change and development in Bist Doab, or for that matter Punjab or even India, and secondly, to suggest the key elements in the processes involved in the change from subsistence to commercial agriculture. The rich experiences of the transformation of agricultural economy in Punjab also raise a series of warning signals that must be very carefully considered in the determination of the future development possibilities, policies and programmes. It is hoped that the study will be provocative of further observation, thought and service.

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LIST OF ABBREVIATIONS

B.D.P.O.	Block Development and Panchayat Officer
CAMAP	Computer Areal Mapping
CDP	Community Development Programme
CMS	Choropleth Mapping System
D.D.P.O.	District Development and Panchayat Officer
HYV(s)	High Yielding Variety (s)
HYVP	High Yielding Varieties Programme
I.A.A.P.	Intensive Agricultural Area Programme
I.A.D.P.	Intensive Agricultural District Programme
I.A.R.I.	Indian Agricultural Research Institute
I.C.A.R.	Indian Council of Agricultural Research
M.F.A.L.	Marginal Farmers and Agricultural Labourers Agency
NES	National Extension Service Programme
N.C.A.E.R.	National Council of Applied Economic Research
P.A.U.	Punjab Agricultural University
S.F.D.A.	Small Farmers Development Agency
SPSS	Statistical Package for the Social Sciences
V.L.W.	Village Level Woker

PREFACE

The transformation of agriculture in the developing countries has been one of the most spectacular features of the past two decades. The generalisation on change, however, includes many complex variations in processes, attitudes, and responses of the people involved. In this thesis, the specific case of Bist Doab, Punjab has been investigated to unravel these complex processes and to identify and analyse the changes which occurred during the period 1951-1968. Subsequent developments were inevitable and many changes, seen and unforeseen, have occurred since then. These changes are significant. On the substantive side, they represent marked improvements in the agricultural production mix, but on the other side, they reflect the vulnerability and unstability of the emerging patterns of development.

Two brief visits to the area, from October, 1970 to January, 1971, and from September to November, 1972, provided opportunities to witness these changes and to feel the effect on the pulse of the local and national economy. The assistance and co-operation of many friends back home was invaluable in procuring facts and figures deemed essential for a realistic perspective and these are gratefully acknowledged. A judicious effort albeit limited, has been made to incorporate these changes as a sequence in the process of development.

A glossary of agricultural terms used, botanical names of crops and Panjabi/Hindi words used in the thesis, is presented in Appendix I. The Harvard system of referencing is used. Page numbers are given in the text only when the reference is to a book or a quotation. Since the statistical data were in Imperial measures, the Metric System is not used.

The location

The triangular territory enclosed between the Sutlej and the Beas rivers is generally known as 'Bist Doab' - meaning the land between two rivers, Sutlej and Beas (see Glossary). The area, almost 90 miles in length and greatest width, forms the north-eastern part of the Punjab State, skirting the Himalayas to the north and sloping gradually to the Indo-gangetic plain in the south. The sub-montane part belongs to Hoshiarpur district, while the rest is divided between Jullundur and Kapurthala districts (Fig. i).

With an area of 3,517 square miles and a population of 2.44 millions in 1961, Bist Doab has a density of 695 persons per square mile - much higher than the corresponding figure for the Punjab State as a whole (565 in 1961). State Revenue Records designate 23 towns and 3,669 villages (Fig. ii), constituting 30 assessment circles. The entire region is divided into the following administrative divisions, as on March 31, 1969 (Fig. iii).

District	Tahsil	Sub-tahsil
Hoshiarpur	Hoshiarpur	Bhunga
	Garhshanker	Balachaur
	Dasuya	Mukerian
Jullundur	Jullundur	-
	Nakodar	-
	Phillaur	-
	Nawanshahr	-
Kapurthala	Kapurthala	Sultanpur
	Phagwara	

Review of previous work

The author is not aware of any other geographical investigation into agricultural changes in the region of Bist Doab. Bhardwaj (1956) and Singh (1960) are the only two studies connected with the agriculture of the region. Bhardwaj (1956) studied soil erosion and land-use in Bist Doab, but confined himself to the description and mapping of land use (based on 1951-52 estimates) in only nine villages of the region. Singh (1960) studied agricultural development in Hoshiarpur district, taking the assessment circle as a unit, for the period 1938-57. Hoshiarpur is only one of the three districts which form Bist Doab region and the study was limited in its scope as compared with the present work.

The district gazetteers (1915), the settlement reports (1875-1915) and the economic enquiries (1937-68) are other official documents covering agriculture in a very generalised way. In addition to these, a few elementary reports - each covering one or other aspects of the problem - have also been published from time to time.

Organisation of the thesis

Part I of this thesis identifies the problem, states the objectives and proposes the hypotheses. It also describes the sources, form and nature of data and establishes the methodology to be pursued.

Part II gives an account of the physical environment - topography, drainage, soils, climate and water resources - of the region. The part played by each of these factors singly or in combination in favouring or impeding agricultural development is assessed.

An appreciation of the human element - attitudes, goals, social and economic status, and technical abilities of the people - which govern the exploitation of the physical resources is as important as the facts of physical environment. The analysis of the human element appears in Part III.

Against this background, the emerging land-use and cropping patterns are described and analysed in Part IV. Some of the emerging features and themes are pursued in case studies which include an application of Von Thunen's celebrated model (modified form) of the location of agricultural production. A synthesis of these emerging patterns is attempted by way of ranking of crops, localisation of specialised crops and by delineating crop pattern regions.

The spatial and regional analyses of changes in land-use and cropping which took place during the period under review is then presented in Part V. The importance of irrigation in agriculture in Punjab is assessed and the analyses of other agronomic changes is sought.

In the concluding Part, the processes involved in change are outlined. A perspective on agricultural development and importance of diffusion is presented and the implications of the system are assessed. The study concludes with the verification of the hypotheses.

PART I

INTRODUCTION

> Ideally, each investigation in agricultural geography should involve four stages: the identification of a problem; the formulation of a hypothesis or hypotheses; the collection of the relevant data; and the testing and modification of the hypothesis to provide an adequate explanation.
>
> (Coppock, 1969: 11)

The aim of this part is to introduce the problem; to underline the objectives and to propose hypotheses; to describe the sources, form and nature of data; and to establish the methodology in order to verify or refute the proposed hypotheses. The testing of these hypotheses is carried through out the rest of the text which hopefully, will provide sufficient explanation.

CHAPTER 1

THE PROBLEM, THE OBJECTIVE, THE HYPOTHESIS, THE DATA, THE METHOD

THE PROBLEM

Developing countries

The problems of agriculture in the developing countries are varied and many. Though the precise nature and sequence of these problems differ appreciably, not merely as between different countries of the developing countries, but also between different areas of the same country, the questions that have to be faced are quite common and, indeed, inescapable in the agricultural development. Myrdal (1971: 416) writes:

> Agriculture is by far the largest sector in the economies of all under-developed countries. Normally more than half - and in most under-developed countries anything up to 80 per cent - of the total population earn their living from the land. The immediate cause of poverty, and thus of under-development, in these countries is the extremely low productivity of labour in agriculture.

Moreover, agriculture constitutes over 50 per cent of the national income of developing countries. Considering these two factors, agriculture is essentially the most important economic activity in the developing world and economic development there must largely imply rural development (Balogh, 1966).

The predicament of agriculture in developing countries is principally one of steadily increasing pressure of population upon restricted and deteriorating resources. The obvious lag of agricultural development, has, therefore, led to low average labour productivity and low national product per worker. These features of agriculture of these countries stem from poor and backward society whose farming techniques are largely traditional.

Tradition is evidenced in fragmented, small sized farms, low capital investment, simple and unsophisticated working equipment, lack of use of chemical fertilizers, lack of quality seeds and crop-protection chemicals, defective land tenure and irrigational practices. Low levels of education and health are further hindrances. Peasant farmers are 'hard-headed' and regard traditional practices as providing security. Thus, for the peasant, 'innovation often seems to constitute a direct attack on his way of life or a complete break with it,' (Dumont and Rosier, 1970: 46). Myrdal (1971: 98) appropriately summarises the position when he writes that:

> ...behaviour patterns in underdeveloped countries are deeply rooted in attitudes hardened into mores by a long historical process. They have been given a foundation by institutions, particularly those of economic and social stratification, in the first hand related to land ownership and tenure, that have been consequential in determining the use of land.

Certainly such a system of agriculture would yield low agricultural productivity and hence cannot keep pace with the rising demand of growing population of the developing countries. Hence, any economic development demands an improvement of agricultural production. (Hodder, 1968), which cannot take place until a change is introduced in the existing agrarian structure. In fact it would mean 'breakdown of an equilibrium' which the farmers have achieved with the 'physical and economic milieu' (Schultz, 1965). To break this equilibrium, a set of new scientific factors are to be introduced. However, 'The failure to grasp the vital principles of interactions is the greatest present technical handicap to agricultural development in the newly developing countries' (Kellogg, 1963: 16).

India and Punjab

Agriculture has been and is still the premier industry of India, engaging 70 per cent of its population and contributing over 50 per cent of the national income. Obviously, the agricultural sector is by far the largest by employment standards, but it is much smaller in terms of total output. The need, therefore, to raise productivity in agriculture is manifest.

The basic problems of agriculture in India (including Punjab) are not much different from their counterparts in the developing world. They have long been recognised and subsequent efforts to overcome them were also made. The establishment of the Agricultural Research Institute at Pusa in 1904, and setting up of the framework of an agricultural administration by establishing an Indian Agricultural Service, as a centralised cadre in 1905, were some of the early positive steps taken to cope with these problems. In 1924, Albert Howard published his first scientific account of the problems of crop production in India. The seriousness of the agricultural deterioration can be realised from the fact that in the 1920's, India became deficit in foodgrains. Another blow to this depressing situation came in more modern times when the Pre-Independence India was partitioned in 1947, with vast areas producing foodgrains being allocated to Pakistan.

In order to overcome these problems and ultimately improve the food situation, India launched a massive programme of rural reconstruction through the Five-Year Plans and other allied projects. The result was that foodgrains production rose from 54.9 million tons in 1950-51 to 107.0 million tons in 1970-71. Despite this considerable increase in agricultural production - which helped maintain the precarious balance between the rising population and the production of foodgrains - the basic problems of agriculture remain.

(i) The outstanding problem of Indian agriculture is the high man-land ratio. Up to early decades of the twentieth century, agriculture in India presented few problems, for the population was limited and land was relatively abundant. Indian agriculture ploughed its own furrow on the traditional pattern and it worked. With the improvements in public health measures, population began to rise at a much faster rate (21.5 per cent during 1951-61 and 24.5 per cent during 1961-71). The result was that foodgrains production could not keep pace with the rising population.

(ii) The bulk of the rural households are constituted of small farmers, as is evident from the simplified estimates given in Table 1.1.

TABLE 1.1 DISTRIBUTION OF HOLDINGS AND AREA BY SIZE

Size of holdings (acres)	Per cent of households	Per cent of area operated
under 2.50	40.70	7.71
2.50 - 4.99	22.26	12.17
5.00 - 7.49	11.85	10.88
7.50 - 9.99	7.00	9.07
10.00 - 14.99	7.62	13.85
15.00 - 24.99	5.83	16.62
25.00 and over	4.74	30.70

Source: National Sample Survey, 16th Round, 1960-61, No 113

From the Table 1.1, it is clear that 63 per cent of cultivators own less than five acres and account for only 19 per cent of the area operated. On the other hand, a little less than 5 per cent of the farmers own 25 acres or more, and together command as much as 31 per cent of the area operated. This indicates extremely uneven distribution of land. Moreover, the average size of the farm is uneconomically small, i.e. 6.6 acres (National Sample Survey, 1960-61).

(iii) The fragmentation of holdings, primarily the result of the existing laws of inheritance, further adds to the difficulties of the farmers. According to the Hindu Succession Act, July 1956, the female heirs also have the right to share (though it was only with the male heirs before) their ancestral property - making the system more complicated and unpractical. The average size of holding of 6.6 acres was on the average constituted of 5.82 fragments (supra). Spate and Learmonth (1967: 261) correctly sum up the matter:

> ...the wealth of the sub-continent lies in its fields - fields often fragmented into mere rags of land, torn by erosion, tilled for so long without rest or fertilisation that over large areas they seem to have reached the ultimate base-level of infertility; and yet ultimately responsible for the subsistence of some 550,000,000 souls.

Such fragmentation leads to enormous waste of time, labour and energy and subsequently results in inefficiency of agriculture. Though consolidation has been in progress since the beginning of the First Five-Year Plan, the success has been only partial and limited in its significance.

(iv) Land tenure still poses a problem, inspite of some significant changes which took place during the last twenty-five years. According to the 1961 census, 76 per cent of the cultivators were owner-cultivators, 15 per cent owner-cum-tenants and 8 per cent purely tenant-cultivators. These figures however, are not free from scepticism, as the law is often evaded through a variety of informal crop sharing agreements. The system lacks security and often '...provisions about security were implemented by their violation' (Konar, 1969: 7).

(v) The indigenous implements, which are known for their inefficiency and small output, still dominate the agricultural scene. The percentage of the main farm implements (National Sample Survey, 1954-55) is given below:

Ploughs (wooden)	68.91	Tractors	0.03
Ploughs (iron)	2.87	Oil engines	0.28
Harrows	36.45		

Though most of them are being gradually replaced by better or improved implements, the process has been very slow.

(vi) Most of the land still lacks proper irrigation. The annual crop, never assured, depends largely on how plentiful the monsoon rains are. Moreover, the existing irrigation system is of an extensive nature and is designed to supply supplementary irrigation during the monsoon. It does not provide intensive irrigation for the whole year. Wasteful irrigation practices further reduce efficiency.

(vii) Lack of capital is another serious handicap. Most of the farmers are in debt and any capital for development has to be borrowed. About 54 per cent of the farmers were in debt to the average extent of Rs. 470/- in 1960-61 (National Sample Survey, 1960-61). Credit facilities are insufficient and mostly beyond the easy reach of the small, illiterate and poor farmers, who form the major part of the farming community.

(viii) Inadequate and untimely supply of inputs, such as fertilizers, seeds and pesticides, further hinder growth. With the new technology creeping into the system, the demand for these inputs is fast increasing. The government, however, for various reasons, is finding it difficult to meet this increasing demand.

(ix) Marketing and storage facilities are inadequate and inefficient. Poor means of communication add to the problem of marketing and storage.

(x) The extension service is also inadequate and poor in quality. Research facilities too are far from satisfactory. Efforts are being made to improve these facilities, but much still needs to be done. A lot depends on funds which the government can make available for research facilities and extension services.

THE OBJECTIVE

The study is primarily concerned with the changing cropland use in Bist Doab, during the three Five-Year Plans period and has the following specific objectives:

(i) to capture the emerging patterns of cropland use and cropping;

(ii) to map; describe and analyse the changes which have taken place since 1951, the year the first Five-Year Plan was launched; and

(iii) finally to investigate the processes involved in the change.

THE HYPOTHESIS

Agricultural development, being the growth and change of the whole agrarian structure, involves a combination of physical, human, economic, social, technological and political factors. All or any of these may have played a major role in the transformation of the agricultural scene, but to assess the significance of any particular factor in isolation is not merely difficult, it is irrational too. Hunter (1969: 115) sums it up well:

> ...to change peasant agriculture, neither the choice of one or two super-priorities, nor an incomplete 'package', nor the introduction of some large discontinuous change in the hope of 'spread' effects, is a complete alternative to the impossible task of doing everything at once.

Agricultural change is a process of 'linked stages' in which the introduction of the first factor prepares the necessary ground for the next.

However, it may be possible in theory to single out factors which seem to make an extremely important contribution and without which no significant change could possibly occur. In the present study these factors seem to be (i) provisions for effective and reliable irrigation and (ii) the response of human element to new innovations.

> The expansion of agricultural production in the countries of the Third World depends as much on the peasant communities' capacity for change and reaction to new ideas as it does on the use of new methods or the reclamation of new land.
>
> (Dumont and Rosier, 1970: 46)

THE DATA

The sample

The problem of scale has had a commanding control over the procedures to be adopted in undertaking this study. The study of all the villages (3,669) would have been very difficult and time consuming, though not impossible. Therefore the need of a sample was pressing. Consequently a more intensive study of 360 sample villages (a village being the smallest unit for which the data are available) which are representative of larger areas and ultimately of the whole state, has been undertaken for present purposes.

In this study, the Systematic Grid Sample method has been used. A similar method was adopted by Singh (1967). The region has been covered by a network of grid lines. On a map of 1 inch: 4 miles, 1 inch: 1 mile grid squares have been drawn. All those villages falling immediately under the inter-sections of the grid lines were chosen as sample villages. This formed only 8 per cent of the total villages of the area. To make the sample more representative, the villages in the centre of the grid squares were later also included. This made the sample approximately 10 per cent of the total.

The points selected by this method may not form a random sample but the method of sampling used in the present study is not likely to introduce any bias. 'Milne (1959) observed ... that the square grids with a point in centre is better than simple random sampling and slightly better than stratified random sampling' (Cochran, 1963: 228).

The sample was further analysed on the basis of the area sizes and the percentage break-up of the sample in each stratum, comes to as given below:

Categories:	I	II	III	IV	V
Area (square miles)	Below 1.00	1.01-2.00	2.01-3.00	3.01-4.00	Above 4.0
Total villages in each category	2,601	716	194	82	76
Sample villages in each category	257	70	18	8	7
Percentage of sample to total	9.5	9.8	9.3	9.8	9.2

The approximate equality of the percentages here also support the representative quality of the sample.

Sources of data

Detailed statistical information on agriculture, population, rainfall and livestock is available at the local offices of the state and are easily accessible. The main body of the data used in this study comprises:

(i) the agricultural returns for each of the sample villages and all assessment circles for each of the 17 years (1951 to 1968), representing 17 matrices of 360 by approximately 350 items of information, and

(ii) the population census of each of the villages for each of the two census (1951 and 1961), representing 2 matrices of 3,669 by 35 items of information.

These statistics were collected personally from different sources which are detailed as under:

A. Primary sources

I. Official documents 1. Agriculture The land-use and crop acreage for all the villages, assessment circles, tahsils and districts is contained in three statistical tables and they include:

(i) Land-use, Table No. 1

(ii) Summer (Kharif) crops, Table No. 2

(iii) Winter (Rabi) crops, Table No. 3

2. Land tenure and ownership The details of land tenure and ownership with a considerable breakdown are given in Table No. 7.

The return for items 1 and 2 above are recorded in the Lalkitabs (Books). The inventories are prepared by the village Patwari (Accountant) and Kanugo (Circle officer). Thereafter these returns are passed on to the tahsil, then to the district, and finally to the State Land Records Office, in a consolidated form for further compilations. These Lalkitabs are prepared bilingually and in duplicate (in order to cover the risk of one of the copies being lost or damaged) and are subject to periodic inspections by the higher revenue officials.

The land-use and crop classification is comprehensive and meaningful. Each category has been precisely defined and the categorisation was considered adequate for the purposes of this study too. Under each major category of land-use and also of all the crops, statistics are given separately for each of the different types of land, for example irrigated (well, tube-well or canal), rainfed, and so on. The crop failure, if any, for each item is also shown.

3. Livestock The complete census of livestock on the village level was first conducted in 1930, and since then it has been conducted every five years with a complete breakdown in terms of age, sex and the purpose for which the livestock is kept. Estimates of livestock production are however not available.

Neither does the census take into account the quality of the livestock. The statistics are contained in the livestock census register at the tahsil headquarters.

4. Irrigation The details of irrigation for each crop, method of irrigation, and the general rainfall conditions for each season, form a part of the Tables 1, 2 and 3.

5. Rainfall The statistics for rainfall and other climatic variables are collected by (i) all the tahsil headquarters and (ii) the Indian Meteorological Department, from their independent sources. The Director of Land Records, Punjab, collects these statistics from the tahsils, and after carrying out the necessary adjustments as suggested by the Indian Meteorological Department, compiles and publishes these data in the form of an annual report. The data used in the present study are largely based on the estimates of the Director of Land Records, Punjab.

6. Population A very comprehensive account of the population is given in Part IV of the District Census Handbooks (published). These data for both the census i.e., 1951 and 1961 were readily available at the district headquarters and at the office of the Superintendent of Census Operations, Punjab, Haryana and Union Territory of Chandigarh, Circle.

II. Field studies A thorough first-hand knowledge of the region under study and intimate personal contact with its people - first as a student and afterwards as a teacher - have helped considerably in conducting this study.

Field studies of some selected villages and farms were also conducted. These included (i) the procurement of Shajra (village map) showing field boundaries, location of wells and tubewells, canals, minor paths and roads (if any) and sites of habitations, (ii) recording of crops in each field, which is referred on the village map by a Khasra number (serial number) and also the details of whether the field was irrigated or not and of any crop failures, and (iii) recording of ownership and tenancy from the Jaman Bandi (cultivators register) for all fields, wells, habitations, paths, roads, village common lands, ponds, etc.

III. Interviews Information collected through interviews of farmers, agriculture and revenue officials, on various aspects of land-use, tenancy and ownership arrangements has also been added to this body of data.

B. Secondary sources

Secondary sources include primarily the published reports and abstracts of a variety of facts and figures. Important among these sources are:

(i) The Economic and Statistical Organisation, Punjab, Chandigarh.

(ii) Director of Land Records, Punjab, Jullundur.

(iii) Land Reclamation, Irrigation and Power Research Institute, Amritsar.

(iv) Directorate of Extension Education, Punjab Agriculture University, Ludhiana.

(v) Director of Agriculture, Punjab, Chandigarh, and

(vi) various other allied departments.

These sources provide a rich background material and also contain a vast amount of information about such things as floods, waterlogging, land reclamation, soil conservation, education, health, yield, production and prices of crops, seeds, fertilizers, pesticides and markets.

The combination of these sources of data provide very comprehensive, integrated and mappable information using the village, farm and field as a frame of reference.

C. Reliability and comparability

Since the present study is mainly concerned with the recording and analysing the changes in land-use and cropping patterns over a period of 17 years, it is essential to establish (a) the accuracy and (b) the comparability, of these data. The following points may be relevant in this regard:

(i) The system of recording these estimates has been homogeneous throughout the period of study i.e., from 1951 to 1968.

(ii) The component areal units for which the data have been used were consistent in respect of area during the said period.

(iii) The coverage of the returns was complete in time and area.

(iv) Since the returns are compiled on a crop-irrigation basis by the revenue department for the purpose of revenue assessment, the importance of keeping them accurate and up-to-date is obvious.

(v) The data contained in these returns generally agreed with those gathered for the same period from other independent sources and compiled by other organisations than the revenue department. The similarity achieved by the distribution patterns of net area sown, intensity of irrigation and rural population, confirms the validity of these data. Furthermore, the fluctuations in harvested area coincided with the annual variations of rainfall.

Two possible sources of error may be mentioned (1) Deliberate false recording and corruption, This is checked by (a) spot checking of the entries by the higher revenue officials and (b) further cross checking, carried out by the officials of the canal (irrigation) department, and (2) Intercropping. This is a common practice and minor crops in the mixed cropping are mainly ignored. It is here that some structural element of error may creep into data. Since the area under mixed cropping is extremely small, the error caused thereby may be set aside.

(vi) The possibility of an element of an inaccuracy as well as inadvertent mistakes in the records has been borne in mind throughout. Cross-checking at the time of computing was done and any discrepancies and omissions which were found were repaired. These were, however, very few.

In view of the above mentioned points, the data used for this study could be considered fairly reliable and rightly comparable.

THE METHOD

Field work was undertaken during the year 1968-69. This involved collection of all available data which would indicate development, changes and trends in the agriculture of Bist Doab. This was possible only with the co-operation of revenue and other allied departments' officials, Government of Punjab, who offered every assistance and provided access to the records and documents.

McMaster (1962: ix) suggests three main approaches to the geographical study of subsistence agriculture, namely (i) an ecological approach, (ii) the land utilization approach, and (iii) a statistical approach. In the present study a statistical approach has been adopted, as it was thought that the present statistical data can reliably be used to establish the spatial and regional characteristics of agriculture and to analyse the changing cropping patterns thereof. The use of the statistical approach was facilitated by the existing digital computer facilities which made it possible to handle successfully a large body of agricultural and population data.

Any statistical approach is limited by the quality of the official information upon which it is based. The reliability and comparability of the data has already been established. The specific models used, where necessary, are given at the appropriate places in the text, while the general strategies applied are as under.

The primary agricultural data contained in different tables for the period of 1951 to 1968 were averaged and transferred to specific proformas for convenience in computing, after grouping the various items into basic enterprises and the details of which are given below:

Table	Total variables	Grouped variables
1	45	30
2	140	60
3	140	60
7	25	15

In the case of the population data of each of the two census (1951 and 1961), each representing 35 items, were grouped into 15 variables in all.

The grouping of items was done on the basis of (i) the relevance of the enterprises in the context of the present study, and (ii) the average weight of the enterprise on the basis of the proportion of the area occupied. Apart from those crops which are either intended for stock feed or cover a very minor proportion of the net sown area, such as pulses, spices, orchards, oilseeds, vegetables, etc., etc., the principal food crops and major cash crops were identified separately as it was thought that (a) the changes are mostly confined in this set of crops and (b) these cover 85-90 per cent of the net area sown - hence changes in them would be more meaningful.

The averages were worked out as under:

(i) Since years of good and bad weather are sometimes bunched together and in that case, fluctuations are large, single year figures or even short-term averages could be deceptive. Hence to eliminate the effects of random fluctuations due to weather and subsequently to attain more reliable picture of the changes, quinquennial averages are largely used, such as 1951-56, 1956-61 and 1961-66 (corresponding to three Five-Year Plans).

(ii) In order to give an objective picture, a perspective rather than an accurate profile of emerging land-use and cropping patterns as a result thereof, three year averages, that is, 1966-68 (corresponding to three Annual Plans) are used.

(iii) For reference purposes, if any need arose, the figures for the year 1951 were kept as single year figures.

These data were then transferred to 80 column punch cards, which made analyses possible by card sorters, interpreting machines and computer programmes, notably 'GIMMS' (Waugh, 1973) and 'Statistical Package for the Social Sciences' (Nie et al., 1970).

Analyses have been undertaken with both absolute numbers and percentage values. The methods applied include the use of Regression, Correlation and Variance techniques. To demonstrate the spatial arrangement of agriculture around settlements and urban centres (markets), Von Thunen's celebrated model (modified) is used, as it was thought to be of particular interest (Coppock, 1969) to agricultural geographers. Cluster analysis techniques were applied to delineate regions.

Field studies, data collected therefrom, and observation made during the field studies, form the basis of the present analyses and discussion. Information collected through interviews has also helped to synthesize with the statistical analyses. The correlation of field observations and data have been demonstrated. The essential matter so derived from the combination of all these is presented in the tables, graphs, diagrams and maps, systematizing a large body of the data into this present thesis. These in themselves will provide adequate explanations.

Most of the maps are choropleth maps in which the areal differences in the importance of particular elements are shown by the differences in the density of shading. The choice of class intervals is a compromise between three ideals: the quartile method, the selection of values grouping areas with similar physical, economic and human characteristics, and finally the production of the map which can be effectively comprehended.

Automated cartography has made a significant contribution to all of these. The computer techniques used include the use of CAMAP, SYMAP and CMS method. Most of the maps are computer maps.

PART II

THE PHYSICAL ENVIRONMENT

The physical environment - relief, drainage, climate, soil and subsoil water - influence the crop growing milieu in many ways. These determine the type of crops, the degree of urgency in timing of agricultural operations, the extent of risk involved in agriculture and in improvements of agriculture, the comparative needs for water and soil conservation, and the opportunities for and relative emphasis on, livestock-keeping as a part of agriculture.

The plant response is conditioned by the total environment. Thus the response to individual environmental factors is not only difficult to measure, rather, to stress it unduly is to 'falsify the geographical reality' (Beaujeu-Garnier, 1968: 52). The human, social and economic factors clearly influence the choice of farming systems, yet they can operate only within the limits set by the physical environment - especially in the case of India - or for that matter developing countries, where the farmer is still a long way from that stage of economic and technological advance, when he escapes from the actualities of physical environment.

In this part, the effect of the factors of physical environment, which appear relevant on the pattern of agricultural activities, will be taken up.

CHAPTER 2

THE LAND

Bist Doab presents an interesting picture both in rocks and land-surface forms. A part of the Doab in the north-east is hilly and is occupied by Katar Dhar Range, which is a continuation of the Siwalik System. The south-west section, however, forms part of the Indo-gangetic plain of India. The plain is almost flat, lying between 700 feet to 1,200 feet above sea-level, while the hills in the north-east lie at 1,200 feet to 2,000 feet. The choe-infested part of the plain is quite conspicuous just at the foot of the Katar Dhar Range.

GEOLOGY

Geologically Bist Doab comprises the north-western part of the Indo-gangetic plain. Wadia (1966) and Krishnan (1960) suggest that Bist Doab falls into two main divisions:

1. Areas of alluvial formation (Pleistocene system)

The deposition of the alluvium commenced after the final phase of the Siwaliks and has continued through the Pleistocene upto the present. The exact depth of the alluvium is not known, but recent gravity, magnetic and seismic explorations show that it is variable, from less than 3,000 to over 6,000 feet. From geological and geophysical survey of Hoshiarpur district (Uppal, 1964) it was found that the sub-strata are very much stratified. Thin lenses of fine sand or even coarse sand occur between layers of clay.

On the basis of test wells in Hoshiarpur and Adampur in the foothill zone, it was concluded 'that in greater part of the Punjab Plains, particularly in the south, the basement is directly overlain by the Siwaliks and recent sediments'. (Dutta, et al., 1964). Some indication of the basement configuration of the Gangetic trough is obtained from the recent exploratory borings put down for water or oil. It is found that the floor of the deposits is not an even plane, but is corrugated by inequalities and buried ridges of variable magnitude. One such ridge has been surveyed running south-eastward upto a distance of 100 miles from the Salt Range in Pakistan, as is evident from the Geodetic Reports of 1934-36. These geodetic surveys revealed the existence of a continuous sub-alluvial ridge, below the alluvium of Pakistan's rivers, with its visible parts represented by the Sangla, Chinot and Kirana Hills (in Pakistan). It has been thought by many investigators (Audin, 1950 and Uppal, 1953) that beyond Sangla, the ridge has been concealed under the Punjab Plains and juts out again near Delhi (Fig. 2.1).

The presence of this ridge of impervious material obstructs the westward flow of underground water from the Doab Plain towards the south-west dry region of Punjab, Haryana and Rajasthan. Although, to a great extent, this has been responsible for providing vast underground water resources in the north-east Punjab, it certainly has contributed to the acute rise of the watertable, causing waterlogging in certain localities in the Doab.

The materials of Bist Doab are of fluviatile and sub-aerial formation. The new alluvium is confined to the vicinities of the Beas and the Sutlej rivers and merges imperceptibly into the flood deposits of sub-recent age. During the rainy season this lowland tract is usually flooded and receives a new layer of the sediment every year, which enriches the soils considerably. It is light in colour and rich in calcareous matter. Generally sand and clay alternate with each other. The old alluvium occupies higher ground and is not liable to frequent flooding. It is dark coloured and generally rich in concretions and nodules of impure calcium carbonate known as 'kanker'. It comprises a mixture of sand, silt and clay, although at certain places a cover of loose sand deposited by numerous seasonal streams is apparent.

In the south-west, sand dunes occur in certain scattered localities. These are usually derived from the nearest open torrent beds, along which sand eroded from the neighbouring hills has been deposited. Another source is, of course, the main river channels which are often miles wide. From both these sources the sand is whipped up by the hot dry summer winds and carried considerable distances away from the actual stream beds. The movement of sand, though, is localised but is none the less a serious handicap for agriculture. Recently, the introduction of tractors in the farming has improved the situation by levelling most of the sand dunes and bringing the land under cultivation.

2. Areas of Tectonic formation (Siwalik System)

The Katar Dhar which forms the north-eastern boundary of the Doab is an outer range of the main Siwalik System. The Siwaliks came into existence only at the end of the second or the early third phases of the Himalayan Orogeny. During these phases was formed a long, narrow depression, called the foredeep, which was the site of the deposition of the Siwalik strata of the Middle Miocene (Krishnan, 1960). Most of the sediments were derived from the denudation of the newly risen mountains. The Siwalik System comprises of sandstones, grits, conglomerates, clays and silt, having the character of fluviatile deposits of torrential streams and floods in the shallow fresh water basin. The thickness of the Siwalik conglomerate varies with distance from the source river.

The significance of these parts is limited to subsistent farming, for these parts impose various problems, such as difficult terrain, soil erosion and water conservation. However, these parts could be of much economic significance, if the timber industry is restored. This needs a serious effort by the Government.

RELIEF

The agricultural use of land is affected by both slope and altitude. The effects of altitude are mainly felt directly, through climate; while slope controls are partly direct, as with the limitation of cultivation by steepness and partly indirect, through climate and soil. In the Doab, both are significant.

The general slope of the region is from north-east to south-west (Fig. 2.2). The gentle gradient, about 1:1,000 over most of the area, is a distinct advantage to crop production, for mechanised equipment can easily be used, and flow irrigation can be provided to its best advantage. Yet during the rainy season, great areas are liable to floods, and in the vicinities of the Beas and Sutlej rivers numerous depressions, which contain this water, are converted into marshes. The gradient in the north-eastern hilly region is steep, 1:100. This region is made up of loose sandrocks, with occasional clays, gravel and conglomerates - which may be called 'an ideal lithology for gullying' (Spate and Learmonth, 1967:535).

Physiographic regions

Physiographically Bist Doab falls into two main divisions, The Hills and The Plains (Fig. 2.3).

The Hills

The Katar Dhar Range of the Siwalik System constitutes the hilly part of the Doab, and lies between the Sola Singhi Dhar on the east, and the Doab Plain on the west. The hills rise abruptly from the plains and run from north-west to south-east as one compact range, except in the extreme south, where they are greatly dissected by the choes flowing on the eastern and western slopes of the range. The southern portion of the Katar Dhar is lower in height, and narrower than the northern. The maximum relief in the south is 1,574 feet above sea level (at Barsaol), while in the north it is 2,382 feet above sea level (at Bah Khushala).

The slope is gentle in the south-eastern section but much steeper in the north-west. These slopes have been cut into ravines by the rainy torrents. Wherever the strata are found inclined and exposed to elements of weather, the softer beds have been eroded and the sandstone can be seen projecting in a confused array of sharp points and deep ridges.

The hills cover the Kandi and Rakkar tract of Dasuya tahsil, the Kandi of Hoshiarpur tahsil, and the Kandi and Bit-Manswal of Garhshanker tahsil. They occupy almost one third of the Hoshiarpur district in the east. This range forms the main water divide between the Soan Valley, in the east, and the Alluvial Plain of the Doab, in the west. The hills of the Doab are 80 miles in length, but the breadth varies from 2 miles in the south to 10 miles in the north. The average height of the hills in this part is 2,000 feet above sea level. On the whole, a gradual slope exists towards the Doab and a steep slope towards the Dun.

The Plains

1) The flat plain Older alluvium or 'Bangar', constitutes the flat plain. It

is dotted by innnumerable fan-shaped Bajadas, formed as a result of sediments brought down and deposited by the choes. Just at the foot of the hills, gravel and conglomerates with shingle, four to five inches in diameter, are observed. Away from the hills, the fineness of sand grains increases. The flat plain covers the major portion of the Doab, constituting a major part of Hoshiarpur and Jullundur districts, the whole of Phagwara tahsil and the eastern part of Sultanpur sub-division.

2) The marshy plain This region is dotted with pools of stagnant water, called Chhambs or Jhils (depressions), where water remains standing throughout the year. During the Monsoon season these depressions are filled with excess rain or flood water. The marshes lie in two long, narrow strips of land (2-4 miles in width) - (i) north-west (ii) south-east - running parallel to the main rivers. The north-western strip is broader and contains more marshy area than the south-eastern.

3) The flood plain This region comprises the flood plains of the rivers Beas and Sutlej, and during the Monsoon season is liable to frequent floods. Due to the menace of frequent flooding, life and property remains at stake and hence the region is virtually uninhabited.

DRAINAGE

The region of study has a distinct and complicated drainage pattern. Two major rivers - the Beas and the Sutlej - drain the area. The other principal drainage channels of the Doab are the East or White Bein and the West or Black Bein; in addition to innumerable hill torrents, commonly known as choes. A line drawn from Hoshiarpur, 1,000 feet at the foot of the Katar Dhar Range to Sultanpur Lodhi, 735 feet above sea level in the extreme south-west, marks the water-divide between the drainages of the north-western and south-eastern parts of the Doab (Fig. 2.4).

The Sutlej

The Sutlej river rises near Manasarowar, at a height of 15,200 feet above sea level, and flows north-westwards as far as Shipki. It cuts through the Zaskar Range near Shipki flowing south-westwards. The principal tributary joining the Sutlej from the north, in the Zaskar Range, is the Spiti river. From the junction with the Spiti river in Kanur (Bashahr), the Sutlej is a rushing torrent right down to the plains, till it changes its direction of flow from south-east to north-west once again, as far as Bhakra. It is here that one of the highest dams in the world has been constructed, 740 feet. Eight miles further down from Bhakra, another headworks has been constructed at Nangal. This multi-purpose river project has contributed much towards the rapid growth of agriculture and industry in Punjab, in particular, and in northern India, in general.

From Nangal onwards, the river takes a southerly direction. Another important stream, known as Soan Nadi, joins the Sutlej in the region from the north. The Sutlej divides itself into many channels immediately south of Nangal township. After flowing for more than 35 miles through the Una *Dun*, the Sutlej takes a westward swing round the Katar Dhar, enters the plains near Rupar and forms the southern boundary of the Doab. At Rupar, there is another very important canal headworks, which provides irrigation to large parts of Punjab. As the gradient is very gentle (1:1,000) in the plains, the speed of the river water is reduced considerably and the river flows through a wide valley. During the Monsoon period, the areas on both sides of the rivers are usually liable to floods. The river leaves the Punjab Plains near Ferozepur and enters Pakistan, forming an International Boundary between India and

Pakistan.

The Beas

The Beas river rises in the Pir Panjal Range at the Rohtang Pass, and flows south-westwards. Its several affluents combine to pierce the Dhaula Dhar Range at Larji. The river flows through deep gorges, until it reaches the outer Himalayas. The upper basin of the Beas encloses the district of Kulu; and in its course through the hills it traverses Mandi and Kangra. From Mandi it takes the turn towards the north-west and traverses through Kangra district of Himachal Pradesh. From Nadaon, it again changes its direction and flows north-westwards. Parallel to the border of Punjab and Himachal Pradesh, another stream, called Sohan Nadi, joins the main stream near Talwara, just after the river enters the Doab.

At Pong village, near Talwara, about 24 miles north-east of Mukerian, a dam, called Pong Dam, is under construction. It is an earth-cum-rockfill dam rising 380 feet above the river bed, and after completion will ensure the extension of perennial irrigation in Bist Doab, other parts of Punjab and Rajasthan. Another connected project is the Beas Sutlej Link, which envisages the diversion of the Beas water into the Sutlej to take advantage of the 1,000 feet fall en route at Dehar (tail of the Link), and another 400 feet fall at Bhakra for the generation of hydro-power and to enable extension of irrigation to the arid tracts in south and south-west Punjab. The project will provide irrigation to command an area of 1,296,750 acres, and the annual irrigation will be in the order of 800,280 acres. Further on, near Hajipur, the river forms the north and north-westerly boundary of the Doab, until it changes its direction to south-west again near Molta to form the western boundary of the Doab. It finally joins the Sutlej near Lohian, at

Hari ke Pattan, after a total course of 290 miles wholly in India. At this point, another headworks, called Hari ke Pattan headworks, has been completed. This canal system will irrigate a major portion of south-west Punjab and Rajasthan.

During the rainy season the Beas floods some parts of the lowland region. To check this usual flooding a flood protection bund (man-made dyke), called 'Dhussi Bund', has been constructed on its left bank, from Dhanoa, about 8 miles north-west of Dasuya, up to the Sutlej-Beas confluence. This 70 miles long earthen dam is about 25 feet high and runs parallel to the river, giving relief to as many as 200 villages and protecting some 70,800 acres of land, (Uppal, 1962) of the Doab.

The hill torrents

There are innumerable hill torrents, locally known as choes, in this region, but, largely because of the intensity of damage that they cause, 85 of them are recognised by the Revenue Authorities.

> The chos [choes] country is really an immense 'pan-fan', in which individual detrital cones are hardly perceptible, while erosion is so violent that the chos are graded from two to four miles (3-6.4 km.) back into the hills - a marked contrast to the usual torrent profile.
>
> (Spate and Learmonth, 1967: 535)

The choes, or khads, originate as small streams in the southern slopes of the Katar Dhar, and widen their channels on their way to the plains. On reaching the plains every choe breaks into a number of branches, and terminates within a few miles from its debouchment from the hills. The choes have steep slopes of 1:150 at the head reaches and 1:600 in the tail portions. As levees are almost non-existent, the branches of the adjacent choes frequently unite, forming a network of sandy beds. All the choes are known for the irregularity of their discharges. They are completely dry except at times of rainfall, when sudden and short-lived floods develop as a result of uncontrolled run off. During the summer season the sand deposited by the choes, becomes very dry, and is blown by the wind, to be deposited indiscriminately over cultivated fields throughout the Doab.

The East or White Bein takes its origin near Garhshanker and drains the excessive water, both surface and ground, of the choes. All the choes west of Hoshiarpur drain into it. It passes through the Garhshanker tahsil longitudinally and then turns to the north, meanders along the Jullundur border and finally enters Nakodar tahsil - ultimately discharging itself into the Sutlej river near Lohian, about eight miles east of the Sutlej-Beas confluence. The water is used for irrigating the crops in both seasons.

The West or Black Bein rises from the Tarkiana near Dasuya, and runs parallel to the river Beas for about 50 miles before falling into the Sutlej river, just near the Beas-Sutlej confluence. It drains the Dasuya and Kapurthala tahsils and drains excess water of the river Beas during the monsoon season, through a regulated dam near Dasuya. The Bein also serves as perennial irrigation channel throughout its length, in the Doab.

SUMMARY

Bist Doab forms the north-western part of the Indo-gangetic plain, and is largely constituted of sand, clay and conglomerates. It has two major physical regions - hills and plains. The general relief of Bist Doab ranges between 700 and 2,000 feet above sea level, with a general slope from north-east to south-west. The region is drained by two main rivers, Sutlej and Beas. Eastern and Western Beins and numerous choes also form part of the drainage system.

Relief and drainage favour agriculture in most of the Doab. The hilly part is rather difficult to develop at this stage of development but future technological advances may help. On the whole, the region provides ample opportunities for agricultural development.

CHAPTER 3

CLIMATE

Although man's influence - from the standpoint of historical, political and economic factors - has been great, climatic factors still are basic in determining the distribution and performance of crops. With the evergrowing mastery over environment, the climatic elements though can be modified, but 'only at some cost' (Coppock, 1971: 29). The peasant farmer of Punjab - even more so of India as a whole - is still a long way from that stage of economic and technological advance when he escapes from the actualities of climate and weather. Hence, in this chapter, the effect of the climatic elements, which appear relevant on the pattern of agricultural activity will be taken up, with tentative generalisations about probable relationships.

The major climatic determinants of plant growth are light, heat, wind and moisture. Out of these, rainfall is the most important, but most variable climatic parameter. It is rainfall - the lack or excess of it - which largely effects the pattern of agricultural activity in the region. Other climatic parameters, though they affect the plant growth significantly, are in no way limiting factors. However, a brief description of these parameters is pursued in the following account, with a comprehensive statistical analysis of the rainfall and its relevance to the agricultural scene.

THE MONSOON CLIMATIC REGIME

A reference to any year's synoptic charts of the Indian sub-continent and its surroundings, would amply reveal that in the north-western parts of the sub-continent a high pressure cell surrounded by low pressure over the Indian Ocean, is well established by December. This happens owing to southward shift of the thermal equator. This high pressure cell is further intensified, and in January the pressure reaches its maximum over Punjab, and consequently over the Doab. With the advance of the year, the temperature starts rising from February onwards, and the high pressure cell gradually weakens towards the end of March. Due to the northward shift of the thermal equator, the temperature continues to rise during April and May until it reaches its maximum in June, when the pressure conditions are completely reversed. Over the whole of Punjab, a 'heat low' is developed. In the beginning of July, with the 'bursting'of the monsoon in Punjab, there is a sudden change in the direction of the winds and tropical marine air masses start to steer towards Punjab. Such conditions remain until August, that is, the end of the wet season. In early September pressure begins to increase with declining temperatures, and from November to January the region is under the control of the high pressure extension, with occassional disturbances caused by the winter depressions. These depressions bring cool season rains, which, though small, are agriculturally significant in Punjab.

Temperature

Owing to paucity of suitable data, a comprehensive analysis of temperature is not possible. Under these circumstances, only general observations regarding the temperature regime are made below:

(i) December and January are the coldest months of the year in Punjab. During these months, the lowest minimum recorded temperature has not fallen below 28.4^{O}F in the last two decades (1949-68), though the average minimum is 32.8^{O}F.

(ii) The fall of temperature below freezing point is very unusual and is limited only to a few days for a few hours in January. This does not seem to have significantly affected the crops in the region.

(iii) The highest recorded temperature during the period is 114^{O}F in June, though the average maximum figure at Jullundur is 111.8^{O}F. Mean monthly temperature is lowest, 53.6^{O}F in January and highest in June, 91.4^{O}F at Jullundur.

Keeping in view the conventionally accepted threshold temperature, that is 42^{O}F, it can be said that the temperature is not a limiting factor in cropping in the region, as the mean monthly temperature is above 53^{O}F. Despite the obvious ill-effects of high temperature, its advantages cannot be ignored. Owing to the high mean temperatures, plant growth continues throughout the year, enabling the cultivation of a wide variety of tropical, sub-tropical and temperate crops.

Seasonal rhythm

In the Doab, as elsewhere in Punjab, agricultural operations are closely associated with the different seasons of the year. There are two very distinctive and effective growing seasons - summer (*Kharif*) and winter (*Rabi*) - in Punjab. With modern innovations such as early-maturing varieties of crops, provisions of irrigation, use of fertilizers, another cropping season is emerging - the hot weather season (*Zaid Rabi*). Taking into account the various agricultural operations, the division into six seasons will be useful in analysing the agricultural pattern of the region. The duration and significance of each season is presented in Table 3.1.

TABLE 3.1 THE CLIMATIC AND AGRICULTURAL YEAR

Climatic Year	Duration	Agricultural Year
Hot-weather season	40-50 days (mid-April to May)	Harvesting and threshing of winter (Rabi) crops, sowing of Zaid Rabi crops.
Harbinger of monsoon	25-35 days (June)	Preparation for summer (Kharif) crops.
Rainy season	70-85 days (Early July to mid-September)	Harvesting of Zaid Rabi crops, sowing and weeding of summer crops.
Season of retreating monsoon	40-45 days (mid-September to November)	Harvesting of summer crops, preparation for the sowing of winter crops.
Cold-weather season	80-100 days (December to February)	Sowing of late winter crops, watering and weeding of winter crops.
Post-winter season	30-40 days (March to mid-April)	Watering, weeding and harvesting of winter crops.

In the beginning of the cold-weather season in December, the temperature has fallen considerably. From mid-December to January, the cool and mainly dry season is at its height. Nights are chilly and morning fog is not uncommon in Punjab. Mean temperatures during this season range between 53°F and 62°F. Relative humidity falls from 90 per cent in December to 75 per cent in February. Westerly depressions, however, are not intense and precipitation, while of useful quantity for agriculture, is not heavy, nor does it persist for long. However, the effectiveness of this rain is enhanced by low temperatures and thus reduced evapotranspiration.

The post-winter season starts from early March, when cyclonic interference normally ceases. However, an occasional late cyclone over the region results in thunderstorms, often accompanied by hail and duststorms, which may cause damage to the standing winter (Rabi) crops. The temperatures are high, $65^{0}F$ - $80^{0}F$, and losses of water through evapotranspiration increases, with a consequent reduction in effectiveness of irrigation. The warm winds, during the last days of May, may result in ripening of the non-irrigated crops too rapidly to preserve quality and yield of the crops.

The heat continues to increase in the hot-weather season, through April and May, until the 'bursting' of the monsoon. The mean monthly temperature ranges from $75^{0}F$ to $87^{0}F$. Relative humidity is the minimum, ranging from 45 per cent in late April to 35 per cent in May. The sky is clear, the days are hot but nights are cool. Hot winds from the south-west start, bringing scorching conditions in Punjab. These winds are locally known as 'Loo'. Outdoor activities are suspended in the midday hours.

June is the hottest month in the Doab, as elsewhere in Punjab, and marks the limit of the harbinger of the monsoon season. The mean monthly temperature is the highest - $90^{0}F$ - $92^{0}F$. Mean relative humidity is only 40 per cent. The days are cloudless and the air is dry. Duststorms of varying magnitude and duration are very frequent, especially in the afternoons and can damage the mango crop, which is important in Hoshiarpur district. Sometimes local rain, due to convection currents, helps in easing the drought. The landscape is brown and bare, with the exception of some isolated green patches maintained by irrigation.

In July the bursting of the monsoon over the Doab, as in the rest of Punjab, is something of an emotional experience - a relief after the mounting tension of the last humid weeks of hot weather. With this starts the rainy season, which is the most productive season of the year. Mean monthly temperature ranges between $85^{o}F$ and $90^{o}F$ in the season. The afternoon temperatures are high and uncomfortable in the humid air. Relative humidity is high, ranging from 75 per cent in July, 85 per cent in August and 78 per cent in September. Nights are often hot and sticky, but the landscape is again fresh and green. This is the busiest period of the year for farmers.

The retreat of the monsoon normally takes place from the middle of September. This is a fairly dry month, but sticky and hot. The temperature starts declining rather fast during the months of October and November. Heavy deposits of dew at night are usual and beneficial for the maturing summer crops, and for the sowing and germination of winter crops. The main rice harvest is gathered, and the threshing is done in ideal conditions in October and November. Fields to be sown with wheat, barley or pulses are ploughed. The days are bright with moderate temperatures, and the nights are cool. Mean monthly temperatures range between $65^{o}F$ and $80^{o}F$. Relative humidity lies between 65 per cent and 75 per cent and this is the most pleasant period of the year. From November onwards, the temperature falls rapidly, and once again cold conditions prevail.

RAINFALL

Of all the climatic parameters, rainfall plays the most important role in the life of the farmer in Punjab. While temperatures are rarely so extreme as to arrest plant growth, deficiencies or excesses of moisture, are accepted as normal hazards in agriculture.

> Moisture is an important factor in all crop producing areas. It is the all-important factor in the minimal regions, where the average or normal rainfall is generally necessary for successful crop production. In such areas the systems of crop production must be correlated more or less with existing moisture conditions; as a matter of fact, the entire programme of crop production is more or less dominated by the moisture factor.
>
> (Klages, 1947: 189)

This can be accepted for the region under study.

In the Doab, as elsewhere in Punjab, the uncertainty, variability and ill-distribution of rainfall, sometimes obstruct the best efforts of the farmer. Such features of precipitation in the Doab demand a thorough analysis of the rainfall records. In this chapter, the rainfall analysis is based on the precipitation records of 25 rain-gauge stations for a period of 20 years (1949-68). The rainfall figures for a period of 30 years (1939-68) are used for long-term projections in respect of Hoshiarpur, Jullundur and Kapurthala stations.

The nature and concentration of rainfall

Two periods of rainfall can be recognised in the Doab - the period of primary concentration or monsoon regime, and the period of secondary concentration or cyclonic regime. Monsoon rains (July to September) constitute 75 per cent of the total rainfall. This rain is not only erratic and largely seasonal, but is characteristically torrential in nature. These excessive falls are of great magnitude and are frequent in the region. The detrimental effects of such rains are largely obvious: waste of rain water in the form of run-off, soil depletion and flooding. The cyclonic rainfall, on the other hand, though very small in amount, is significant as it falls in a state of light drizzle, allowing time for its absorption into the ground. The concentration of the rainy days is in the monsoon period (17-20 days), followed by the cold season (7-9 days). Two features of rainfall reduce its usefulness for agriculture in the Doab: (i) its concentration in three months (July to September), leaving the rest of the year largely dry; and (ii) frequency of long dry spells within the wet period.

Distribution of rainfall

Annual The rainfall distribution in the Doab is erratic both in time and space. It decreases from north-east to south-west (Fig. 3.1). The places situated near the Siwalik Hills receive more rainfall than those farther away, viz. Hoshiarpur 36, Jullundur 32, Kapurthala 25 and Nakodar 22 inches respectively. The general pattern of the average annual rainfall distribution is as follows:

(i) High rainfall areas They are Kandi, Bit-Manswal and northern most parts of Sirwal of Garhshanker tahsil, Kandi, Rakkar and most parts of Sirwal of Hoshiarpur tahsil, Kandi, Rakkar, Maira and north-eastern parts of Bet of Dasuya tahsil. They receive more than 35 inches of rainfall annually.

(ii) Medium rainfall areas The rainfall ranges between 25 and 35 inches in Phagwara, Phillaur, Nawanshahr, Jullundur tahsils, south-west parts of Garhshanker tahsil and Dasuya tahsil and some parts of Hoshiarpur tahsil.

(iii) Low rainfall areas These comprise practically the whole of Kapurthala and Nakodar tahsils. The average annual rainfall here is less than 25 inches.

Seasonal Summer The general trend of the summer rainfall is similar to annual (Fig. 3.2). The summer rainfall is distributed over the period from April to September, and largely controls the timings of summer cropping. A delay in the monsoon rains or long dry spells during the growing period of the summer crops would lead to devastating results. Heavy late rains could also damage the standing crops considerably. It ranges between under 20 inches in the south-west, to over 30 inches in the east. Most of the region receives rainfall between 20 and 30 inches. Again, most of the summer rainfall is concentrated in three months, July to September. October is generally dry but rainfall of up to 20 inches (1955) is not unknown, and can result in severe floods and devastations. Yet a reasonable amount of rainfall in October generally improves the harvest.

Winter Winter rainfall (October to March) also has the same trend as summer, and it ranges between less than 4 inches in the south-west, to more than 7 inches in the east (Fig. 3.3). Though small in amount, this rainfall is very useful for the winter crops. Most of the rain falls between mid-December and the end of February. A dry January is not unknown, though it happens rarely.

Monthly The monthly rainfall dispersion diagram set out in Figure 3.4 illustrates the general distribution of actual rainfall for ten main stations of the Doab, for a period of 20 years (1949-68). From the figures, the following observations can be made:

(i) The primary concentration of rainfall over all the stations, is during the monsoon period, that is from July to September.

(ii) The secondary concentration is during the cold season, from December to February.

(iii) July is the rainiest month sharing 30 per cent of the annual rainfall, followed by August (25 per cent).

(iv) November shares less than 1 per cent of the annual rainfall and is the driest month.

(v) North-eastern areas receive more rainfall than the south-western. Hoshiarpur situated in the north-east receives maximum rainfall, and

Nakodar, situated in the south-west, the least.

Trends The inspection of annual and normal (running mean of 50 years) rainfall statistics of the Doab for the last two decades (1949-68) reveal that in most of the years, the rainfall has been in excess in the region. The frequency of the rainfall during this period is shown in Table 3.2.

TABLE 3.2 FREQUENCY OF RAINFALL DURING 1949-68, IN THE DOAB

	Number of years	
Station	Rainfall above normal	Rainfall below normal
Hoshiarpur	13	7
Jullundur	14	6
Kapurthala	12	8

Extending the analysis further, average annual rainfall for the period of 30 years (1939-68) for Hoshiarpur, Jullundur and Kapurthala has been plotted in Figure 3.5. The mean of 30 years is shown in a continuous line. From the figure it is evident that the rainfall has been in excess of the mean in the later half of the period. This indicates a revival of a relatively wet cycle in the Doab. In the case of Jullundur, a regression equation has been calculated. The regression line, though statistically not significant, does indicate a positive trend.

Variability of rainfall

The rainfall varies appreciably in time and amount. It is another feature of the rainfall which compounds the difficulties farmers face in adapting to the climatic regime of the region.

Annual (Fig. 3.6) In regard to annual totals, the northern parts, comprising

TABLE 3.3 SEASONAL AVERAGE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION VALUES OF HOSHIARPUR, JULLUNDUR AND KAPURTHALA, 1949-68

Season	Average (inches)			Standard deviation (inches)			Coefficient of variation (per cent)		
	Hoshiarpur	Jullundur	Kapurthala	Hoshiarpur	Jullundur	Kapurthala	Hoshiarpur	Jullundur	Kapurthala
1. Hot-weather season (April and May)	1.10	1.22	1.01	0.987	0.939	0.918	90	77	91
2. Harbinger of monsoon (June)	2.02	2.27	1.19	2.712	3.373	1.135	134	149	95
3. Rainy season (July to September)	26.65	22.67	18.45	5.266	7.683	5.444	20	34	29
4. Retreating monsoon (October to November)	2.46	2.44	1.16	5.705	4.75	2.774	232	195	238
5. Cold-weather season (December to February)	3.32	2.62	2.15	1.742	1.841	1.752	53	70	82
6. Post-winter season (March)	1.02	1.23	0.66	1.007	1.057	0.753	99	86	114

Dasuya tahsil and northern Kapurthala and Hoshiarpur tahsils, have an average variation of more than 30 per cent. Elsewhere to the south, the average variability tends to decrease. It is less than 25 per cent in Phillaur, parts of Phagwara and Nawanshahr tahsils, whereas in the rest of the Doab it ranges between 25 per cent and 30 per cent. The minimum variability of 21 per cent occurs at Phagwara, while the maximum of over 32 per cent is found at Tanda station. It is evident that annual variability is high throughout the region.

Seasonal The seasonal average, standard deviation and coefficient of variation values for selected stations of the Doab, are given in Table 3.3. The seasonal distribution of rainfall tends to cause a large variability at certain times of the year. From Table 3.3, it is clear that the rainy season is relatively stable with an average variation from the mean, ranging between 20 per cent at Hoshiarpur to 29 per cent at Kapurthala and 34 per cent at Jullundur. This is followed by the cold-weather season with 53 per cent at Hoshiarpur, 82 per cent at Kapurthala and 70 per cent at Jullundur. The most unstable season is that of retreating monsoon when the coefficient of variation is over 200 per cent, followed by the harbinger of monsoon season with a coefficient of variation 100 - 150 per cent. Hot-weather and post-winter seasons record a variability of 75 - 115 per cent.

Monthly Owing to the rather localised nature of rainfall, monthly totals show large variations, and droughts occasionally occur, even in areas where the total rainfall is high. Mean monthly rainfall data with their standard error and standard deviation are presented for the ten main stations of the Doab in Figure 3.7. Each graph is based on a run of statistics covering 20 years (1949-68). The shaded area, lying between ± 1 standard deviation, contains 68.3 per cent of the occurrences and can be read to mean that the

TABLE 3.4 MONTHLY AND ANNUAL AVERAGES, STANDARD DEVIATION AND COEFFICIENT OF VARIATION VALUES FOR RAINFALL OF HOSHIARPUR, JULLUNDUR AND KAPURTHALA, 1949-68

		January	February	March	April	May	June	July
Average (inches)	Hoshiarpur	1.61	1.13	1.02	0.44	0.66	2.02	12.63
	Jullundur	1.35	0.78	1.23	0.43	0.78	2.27	9.59
	Kapurthala	1.80	0.69	0.66	0.43	0.57	1.19	9.25
Standard deviation (inches)	Hoshiarpur	0.912	1.537	1.007	0.637	0.732	2.712	4.023
	Jullundur	1.169	1.427	1.057	0.419	0.894	3.372	4.310
	Kapurthala	1.472	1.066	0.753	0.634	0.705	1.135	2.435
Coefficient of variation (per cent)	Hoshiarpur	57	136	99	146	111	134	32
	Jullundur	87	183	86	97	114	148	45
	Kapurthala	125	155	114	147	123	95	26

		August	September	October	November	December	Year
Average (inches)	Hoshiarpur	9.10	4.91	2.14	0.33	0.58	36.56
	Jullundur	8.12	4.95	2.18	0.26	0.49	32.46
	Kapurthala	6.17	3.03	1.10	0.07	0.38	24.62
Standard deviation (inches)	Hoshiarpur	3.547	5.010	5.708	0.556	0.632	9.148
	Jullundur	4.653	5.570	4.837	0.386	0.721	8.835
	Kapurthala	2.435	3.500	2.791	0.112	0.569	6.191
Coefficient of variation (per cent)	Hoshiarpur	39	102	267	171	109	25
	Jullundur	57	112	222	147	146	27
	Kapurthala	39	115	254	167	150	25

rainfall may occur within this range. Though no specific generalisation is possible, there seems to be a tendency towards increased variability with low mean rainfall and vice versa. Furthermore, it is evident that the monthly variability of rainfall is high, and hence that no simple periodicity can be established.

The monthly and annual averages, standard deviation and coefficient of variation values at the three representative stations of the Doab are presented in Table 3.4. From this table, the following deductions can be made:

(i) The minimum variability (25 - 45 per cent) occurs in July followed by August (40 - 60 per cent).

(ii) The maximum variability of more than 200 per cent occurs in October (222 - 267 per cent).

(iii) In the remaining months the coefficient of variation varies between 50 and 200 per cent.

A two-way classification of analysis of variance was applied to the coefficient of variation, observed in different months at the three representative stations. This analysis, given in Table 3.5, shows that the coefficient of variation does not differ significantly in various months of the year, or at different stations.

TABLE 3.5 ANALYSIS OF VARIANCE OF COEFFICIENT OF VARIATION

Source	Degrees of freedom	Sum of squares	Mean squares	F	
Between stations	2	485.72	242.86	.0099	not significant
Between months	11	102,730.30	9,339.12	.3827	not significant
Error or (stations x months)	22	536,808.98	24,400.41		
Total	35	640,025.00			

It may be concluded that the variability of rainfall is haphazard, and hence no periodicity can be fixed.

Probability of rainfall

Since water supply is a major determinant of agricultural yields, the capriciousness of rainfall can pave the road to bankruptcy in modern agriculture. Indeed, the unpredictable and variable nature of rainfall has, in many areas, made agriculture an unqualified gamble, and it is this aspect that makes it desirable to assess the probability of rainfall as a factor in agricultural production. This could lead to the understanding and planning of the following:

(i) The expansion and use of efficient irrigation system, where possible.

(ii) The need of surface and sub-surface drainage to cope with the adverse effects of excess water.

(iii) The selection of crop varieties which will better withstand adverse supplies of water.

The spatial distribution of annual and wet-season probability is shown in Figures 3.8 and 3.9. The data used are for a 20 year period (1949-68), which is considered to 'provide a precise estimate of expectations' (Manning, 1956: 464) for the period immediately following (Gregory, 1969: 77). The upper and lower limits, for 90 per cent of the occurrences, are fixed for both annual and wet-season rain.

Annual The annual probability of rainfall (upper and lower limits) distributions follow almost similar trends to those of the average annual rainfall: they decrease in amount from north-east to south-west. Both upper and lower probability limits will be taken up separately.

Upper limits (Fig. 3.8a) In regard to the upper limits of the annual rainfall probability, the following categories emerge:

(i) High rainfall probability areas. These include Hoshiarpur, most of Dasuya and the northern most part of Garhshanker tahsils. The probability of annual rainfall in this region lies in the range of 45 inches.

(ii) Medium rainfall probability areas. Jullundur, Garhshanker, Nawanshahr, Phagwara, parts of Dasuya and Phillaur tahsils fall into this category. The rainfall probability ranges between 35 and 40 inches.

(iii) Low rainfall probability areas. These consist of Nakodar, Kapurthala and western parts of Phillaur tahsils. The rainfall probability is between 25 and 30 inches annually.

<u>Lower limits</u> From Figure 3.8b it is evident that the region lying in the south-east, comprising Kapurthala, Nakodar, Phillaur, Nawanshahr, parts of Jullundur and Dasuya, falls into the least rainfall probability - less than 20 inches. It is this factor which suggests a greater risk of crop failure in the region. Elsewhere, the probability of rainfall is more than 20 inches.

From the comparison of these figures, the following observations may be made:

(i) The difference between the average annual rainfall and probable annual rainfall (upper limit) ranges between 5 inches in the south-west, to 10 inches in the north-east.

(ii) The difference between the average annual rainfall and the probable annual rainfall (lower limit) ranges between 10 and 15 inches in the region.

(iii) The gap between the upper limit and the lower limit is 15 - 20 inches. Considering the mean annual values these differences are great, and thus need to be taken into account while determining the water requirements of agriculture.

Seasonal Since 75 per cent of the rainfall is concentrated in three months (July to September), it is desirable to consider these seasons separately. The distribution of seasonal rainfall probability is shown in Figures 3.9a and 3.9b. A study of these figures reveals the following points:

A high probability of rainfall of 30 to 35 inches (upper limits) covers Hoshiarpur district and northern parts of Jullundur and Phagwara tahsils. Elsewhere, the probability is between 20 and 30 inches.

In the lower limit, Hoshiarpur has a rainfall probability of more than 15 inches, while Jullundur and Kapurthala districts have one of 5 to 15 inches. Again, the gap between the upper and lower limits is great, 10 to 15 inches.

It is clear, from this analysis, that extensive areas of the Doab have excess water during three months of the year (July to September), and that lower crop yields and greater crop risks result from this.

Effectiveness of precipitation

In addition to total amount and seasonal distribution of precipitation, it is important to understand the effectiveness of rainfall. This has been considered under a somewhat broader term, 'water economy', by Thornthwaite and Mather (1955). It is in this area particularly that man can exercise a considerable influence.

Measures of effectiveness of precipitation have been suggested by Transeau (1905), Thornthwaite (1931, 1933), Thornthwaite and Mather (1957), Penman (1948, 1956), Budyko (1956) and Schwab et al. (1958). The limitations of the available data do not permit the use of any comprehensive method such as Penman's or Budyko's. The relative advantages of Thornthwaite's, on the other hand, justify its use in the present study.

An effective moisture value is evolved after Thornthwaite and

Mather (1957). These values are based on 20 years averages of precipitation records. These moisture values are significantly related with the yields and quality of crops than the actual rainfall alone. Moreover, the difference between the two values is important in defining the area of water need and 'may serve as first estimate for irrigation' (Davies and Robinson, 1969: 25).

The computation of potential evapotranspiration and precipitation values reveal that potential water loss (negative P-PE) during the year is greater than excess precipitation (positive P-PE), suggesting thereby that precipitation is not sufficient to bring the soil moisture up to field capacity at any time during the year. Figure 3.10 shows the average course of precipitation, potential evapotranspiration and actual evapotranspiration at the selected stations of the Doab. From the figure, the following points emerge:

(a) Potential evapotranspiration exceeds precipitation through most of the year.

(b) There are two wet periods, mid-December to mid-February and mid-June to mid-September; each followed by a dry period.

(c) The primary concentration of soil moisture deficit is during the summer months (April to September).

(d) The winter deficit is relatively low due to least loss of water through evapotranspiration on account of low temperatures.

The water need, rainfall and deficit of soil moisture varies considerably through the year in the Doab. This can be understood from the computation of the water balance for Hoshiarpur (Table 3.6).

From Table 3.6, it is clear that the water need is nominal in November and December - less than 0.5 inches. This is followed by the wet winter months of January and February. The need rises in March and increases

TABLE 3.6 AVERAGE WATER BALANCE COMPUTATIONS FOR HOSHIARPUR, BIST DOAB
(all values in inches)

	January	February	March	April	May	June	July
PE	0.54	1.04	3.09	5.83	7.43	8.07	8.28
P	1.61	1.13	1.02	0.43	0.66	2.02	12.63
P-PE	1.07	0.09	-2.07	-5.40	-6.77	-6.05	4.35
Δ ST	1.07	0.09	-0.86	-1.54	-1.25	-0.69	4.35
ST	5.57	5.66	4.80	3.26	2.01	1.32	5.67
AE	0.54	1.04	1.88	1.97	1.91	2.71	8.28
D	0	0	1.21	3.86	5.52	5.36	0
S	0	0	0	0	0	0	0

	August	September	October	November	December	Yearly
PE	7.52	6.49	4.99	2.11	1.06	56.45
P	9.10	4.91	2.14	0.33	0.58	36.56
P-PE	1.58	-1.58	-2.85	-1.78	-0.48	-19.89
Δ ST	1.58	-0.78	-1.20	-0.64	-0.15	
ST	7.25	6.49	5.29	4.65	4.50	
AE	7.52	5.69	3.34	0.97	0.73	36.58
D	0	0.80	1.65	0.14	0.33	18.87
S	0	0	0	0	0	0

PE = potential evapotranspiration, P = precipitation
P-PE = precipitation minus the potential evapotranspiration,
Δ ST = storage change, ST = moisture storage, AE = actual evapotranspiration,
D = moisture deficit, and S = moisture surplus.

rapidly thereafter, until it reaches its climax in May, 5.52 inches, closely followed by June, 5.36 inches. July and August are wet summer months. Again, September and October experience a deficit of 0.80 and 1.65 inches respectively.

The distribution and variation can be observed in Figure 3.11. The average annual moisture deficit is greatest (over 50 per cent) in the south-western parts of the Doab and decreases towards the north-east (under 40 per cent). The same trend can be found in summer and winter seasons (Figs 3.12 and 3.13). In summer the intensity of soil drought ranges between less than 30 per cent in the north-eastern parts, to more than 40 per cent in the south-west. The central parts have an intensity of 30-40 per cent. In winter, the intensity is relatively higher in most parts of the Doab. The winter soil drought is very significant as it could harm both summer and winter crops and it is this aspect which makes irrigation a necessity. The need for irrigation is increased by the introduction of high-yielding varieties which require an assured water supply.

Potential evapotranspiration can be used for reckoning the need of water in acre-feet per square mile of the cultivated area, after taking into account the actual rainfall. It has been calculated as:

$$\text{Water requirement per square mile of cultivated area} = \frac{\text{Potential evapotranspiration - precipitation}}{12} \times 640$$

Results thus derived are mapped in Figures 3.14 and 3.15, which exhibit the water requirements over and above rainfall in the Doab by assessment circles for respective crop seasons. The water needs during summer are almost three times greater than that during winter. In summer, the water needs per square mile of the cultivated area range between under 750 acre-feet in the north-east to up to 1,250 acre-feet in the south-west. In the remaining parts it ranges between 750 and 1,050 acre-feet. In winter, it ranges from less than 250 acre-feet in most of Jullundur district to 450 acre-feet in Dasuya tahsil. Elsewhere, it lies between 250 and 350 acre-feet per square mile of the cultivated area.

SUMMARY

Of all the climatic parameters, rainfall is the most significant but most variable. While temperatures are rarely so extreme as to arrest plant growth, deficiencies or excesses of moisture are accepted as normal hazards in agriculture. Rainfall is largely concentrated in three summer months, July to September, leaving the rest of the year relatively dry. Winter rain is limited in amount but useful for winter crops. The overall distribution of rainfall tends to decrease from north-east to south-west. The variability of rainfall is exceedingly high in amount, time and space. The probability pattern follows similar trends as actual rainfall. The differences between the average rainfall and probable rainfall are high.

The region is deficient in soil moisture and subsequently water requirements for plant growth are high in both crop seasons. Consequently, the need for irrigated water for crop growing milieu is considerable. Indeed, water remains the most critical factor in agricultural development in Bist Doab or in Punjab, as in the rest of India.

CHAPTER 4

SOIL FACTORS IN AGRICULTURE

Unfortunately, little data on the soils of Punjab, incuding Bist Doab, are available, though the need for a scientific soil survey was realised as early as 1919 (Wilsdon, 1919). Some references were made in the Settlement Reports of the Punjab Government (1875-1912) from time to time, and in 1928 the Royal Commission on Agriculture made recommendations for a complete soil survey of Punjab. Yet these reports and recommendations remained unheeded. The pioneer attempt to study soils was made by Gorrie (1938, 1946). Later, Bhardwaj (1956), a geographer, attempted to analyse the soils of the Doab by collecting soil samples. Another attempt was made by the Punjab Agricultural University, Ludhiana (1960). The Land Reclamation, Irrigation and Power Research Institute, Punjab (Uppal, 1961, 1964), also conducted soil surveys, which were mainly for land reclamation of certain selected areas of Punjab, including Bist Doab. Historically, the study of the soils of Punjab has been primarily directed to single-purpose applications, and little attention has been given to soil potential on a comprehensive, regional basis.

The main functions of the soils, from an agricultural point of view, are to give mechanical support to plants, and store and supply the required nutrients and water for plant growth. These elements - nitrogen, phosphorus and potash - are the essentials for plant growth. A balanced supply of all these elements is important and when any one is in short supply, the plant growth and ultimately its yield and quality are prejudiced. Nitrogen is essential for plant growth, promotes leaf and stem health and gives green colour to plants. Phosphorus is required for root growth, hastens maturity and aids in seed and fruit formation. Potassium imparts plant vigour for developing resistance to plant diseases, drought and winter-hardiness and promotes quality of produce.

The soils of Bist Doab are deficient in nitrogen and have low to medium reserves of available phosphorus. This deficiency must be met through the use of different fertilizers. Farmers are using more nitrogen, and to some extent phosphorus, but very few farmers are adding potassium fertilizers. For balanced nutrition of most of the cereal crops, it has been established that the need for application of nitrogen, phosphorus and potassium in the ratio of 2:1:1 is essential. Compared with this, the ratio of nitrogen, phosphorus and potassium during the year 1968, was only 1.0:0.22:0.6 (Randhawa and Lal, 1970). This clearly shows that the farmers have yet to realise the importance of phosphorus, and particularly that of potassium, in crop production. It is also ascertained (supra) that most of the fodders have a very wide N:S ratio and this can be partly attributed to be one of the causes of poor cattle health.

On the basis of the chemical properties and rainfall, the Soil Department of Punjab Agricultural University, Ludhiana, has prepared a map of soil zones of Punjab (erstwhile Punjab). Bist Doab is covered by three such soil zones (Table 4.1 and Fig. 4.1).

Zone I

It covers parts of Dasuya, Garhshanker and Hoshiarpur tahsils. The soils are mildly acidic to neutral in reaction. They are deficit in nitrogen and phosphorus, but responsive to potash, zinc and iron. Due to historical reasons, the nature of topography, rock structure and rainfall, soil erosion is a serious problem. Wheat, maize, rice and sesamum are the main crops.

Zone II

It covers almost two thirds of the region, comprising Jullundur district as a whole, Phagwara tahsil and the eastern half of Kapurthala tahsil, and western parts of Dasuya, Hoshiarpur and Garhshanker tahsils of Hoshiarpur district. The soils are saline on the whole, but in certain scattered localities alkalinity is also observed. The soils are deficient in nitrogen, phosphorus and potassium. Wheat, rice, maize, gram, sugarcane and pulses are the main crops, although cotton and potatoes are becoming increasingly important.

Zone III

It covers the western half of Kapurthala and Nakodar tahsils. The soils are calcareous in nature and, in most cases, kanker layers occur at 3-5 feet depth. These soils are very deficient in nitrogen and respond to potassium and phosphorus. Salinity and alkalinity is a problem, as is erosion by wind. Wheat, gram, maize, rice, groundnut, cotton and sugarcane are the main crops.

TABLE 4.1 THE CHEMICAL ANALYSIS OF SOILS OF BIST DOAB

	Soil	Soil Characteristics					Climate	Class
	pH	Per cent			Available lbs/acre		Rainfall	Soil
Zone	Range	$CaCO_3$	O.M.	N	N	P_2O_5	(inches)	classification
I	6.5-7.5	0.16	1.00	0.08	114	15	40-60	Acidic-neutral
II	7.0-8.5	0.17	0.80	0.06	98	19	30-40	Saline
III	7.5-8.5	0.24	0.53	0.01	99	20	20-30	Saline-alkaline

$CaCO_3$ = Calcium Carbonate; P_2O_5 = Phosphorus; O.M. = Organic Matter; N = Nitrogen

Source: Punjab Agricultural University, Ludhiana

The farmers have sufficient knowledge of their soils' structure, which they have learnt through the long history of cultivation, although they are certainly ignorant of the chemical properties. Yet it is essential to understand the chemical characteristics of the soil, since both quality and quantity of crops produced depend largely on the amount of plant food available. Such knowledge might help the farmers to apply various simple and compound fertilizers to improve production. As it is, they often have no practical knowledge of soil deficiencies, and are seldom familiar with the special requirements of the crops they hope to grow (with the exception, of course, of a very few educated progressive farmers).

The analysis of interviews with farmers will help in elaborating this point. One hundred farmers were interviewed and the results were as follows:

(i) Five had sufficient knowledge of their soils' deficiencies and requirements. They had their soils properly analysed and would follow the recommendations of the experts, regarding the crops to be grown and the use of specific fertilizers.

(ii) Fifteen had an average knowledge, and had their soils partially analysed. However, they would not totally agree with the recommendations.

(iii) Forty had partial knowledge, and did not have their soils analysed at all. The general recommendations were occasionally accepted.

(iv) Forty were absolutely ignorant of their soils' deficiencies. They ignored all recommendations.

THE AGRONOMIC CLASSIFICATION OF SOILS

The classification of soils tends to vary according to the aims of the survey. Cropland interpretations mainly consider such properties as

TABLE 4.2 PHYSICAL ANALYSIS OF SOILS OF BIST DOAB AS COMPILED FROM THE SOIL SAMPLES

Location/Tahsil	Parts by weight (per cent) and size of particles: Clay Less than 0.002mm	Silt 0.002mm	Silt 0.02mm	Sand More than 0.02mm	*Textural grade	*General category
Bet (Nakodar)	12.10	24.10	14.50	49.30	Loam	1. Loamy soils
Bet (Phillaur)	14.05	18.20	12.05	55.70	Loam	
Bet (Nawanshahr)	13.00	20.00	20.10	46.90	Loam	
Dhaha Bet (Nawanshahr)	18.00	15.90	14.10	52.00	Loam	
Bet (Garhshanker)	14.00	16.40	13.60	56.00	Loam	
Bet (Dasuya)	12.40	30.05	20.05	37.50	Silt loam	
Bet (Kapurthala)	11.00	33.05	18.05	37.90	Silt loam	
Sirwal (Garhshanker)	26.50	23.90	20.00	29.60	Clay loam	
Sirwal (Phagwara)	26.65	21.00	16.65	35.70	Clay loam	
Dhak (Phagwara)	28.30	20.00	13.00	38.70	Clay loam	
Dhak (Nawanshahr)	30.10	18.05	11.45	40.40	Clay loam	
Retli (Nawanshahr)	32.10	12.00	10.00	45.90	Clay loam	
Phillaur (Phillaur)	30.60	16.10	10.70	42.60	Clay loam	
Sirwal (Dasuya)	19.90	15.00	12.70	52.40	Sandy clay loam	
Sirwal (Hoshiarpur)	21.00	16.00	14.00	49.00	Sandy clay loam	
Sirwal (Jullundur)	20.05	16.00	13.00	50.95	Sandy clay loam	
Dona (Nakodar)	16.00	10.50	8.40	65.10	Sandy loam	
Manjki (Nakodar)	14.65	8.85	8.95	67.55	Sandy loam	
Manjki (Phagwara)	14.40	20.30	15.20	50.10	Sandy loam	
Rakkar (Dasuya)	8.00	4.10	5.90	82.00	Coarse sand	2. Sandy soils
Kandi (Dasuya)	6.00	5.20	6.80	82.00	Coarse sand	
Kandi (Hoshiarpur)	4.70	3.10	5.20	87.00	Coarse sand	
Kandi (Garhshanker)	5.10	4.10	6.80	84.00	Coarse sand	
Maira (Dasuya)	9.10	6.65	4.20	80.05	Sand	
Rakkar (Hoshiarpur)	4.65	2.55	5.20	87.60	Sand	
Rakkar (Garhshanker)	3.10	4.30	5.40	87.20	Sand	
Dona Lehnda (Jullundur)	10.10	12.10	9.70	68.10	Loamy sand	
Dona Charhda (Jullundur)	11.00	10.55	9.20	69.25	Loamy sand	
City Circle (Jullundur)	10.10	14.20	8.20	67.50	Loamy sand	
Dona (Kapurthala)	12.30	11.20	7.50	69.00	Loamy sand	
Bit-Manswal (Garhshanker)	45.40	8.20	11.30	35.10	Clay	3. Clayey soils

Source: Fieldwork

* 7th Approximation: Soil Survey Staff; Soil Conservation Service, United States Department of Agriculture: August- 1960

structure, texture, slope and drainage in attaining a grouping of soils suitable for specific agricultural uses. The present discussion of the soils of Bist Doab is, the synthesis of: the Settlement Reports (Punjab Government, Lahore, 1875-1912), the soil sample analysis (Punjab Agricultural University, Ludhiana), the work of the Land Reclamation, Irrigation and Power Research Institute (Amritsar), and the product of personal observation and field inquiries. As such, Bist Doab soils can be grouped into the following categories (Table 4.2 and Fig. 4.2).

I. Loamy soils

1) Loam
2) Silt loam
3) Clay loam
4) Sandy clay loam
5) Sandy loam

II. Sandy soils

1) Coarse sand
2) Sand
3) Loamy sand

III. Clayey soils

1) Clay

I. Loamy soils

These cover more than half of Bist Doab and are medium or fine textured soils. They are fertile and capable of producing a variety of crops such as wheat, maize, rice sugarcane, cotton, grams and various pulses and vegetables. On the whole, these soils are retentive of moisture and thus crops such as sugarcane and maize are grown without irrigation. Clay, loam and silt are found in varying proportions in different parts of the region. Kanker (calcareous nodules) are also found in certain places. These soils are further sub-divided into five categories:

1. Loam The flood plain of the Sutlej river is covered by loam, and includes Bet tracts of Nakodar, Phillaur, Garhshanker, and Bet and Dhah Bet of Nawanshahr tahsil. This consists of newer alluvium, called Khadar, and is a medium-textured soil. Due to flooding of the region during the rainy season, it annually acquires a new layer of silt, which maintains soil fertility. Small streams, known as 'Nallas', drain this region into the Sutlej river. They cut the banks of the river into ravines and form swamps and marshes (Fig. 2.4). Sub-soil water is adequate and well irrigation is easy and economical since the water table is high, 5-20 feet.

2. Silt loam The silt loam, a medium-textured soil tract, is comprised of Bet areas of Dasuya and Kapurthala tahsils, and forms the flood plain of the Beas river. This tract lies between the Western Bein on the east and the Beas river on the west. The area lying inside the Dhussi Bund (man-made dyke), is liable to usual floods, and sometimes the whole tract is under 10-20 feet of water. From a structural and textural point of view, the soil is suitable for cultivation, but on account of waterlogging and soil erosion, deterioration is rapid. The water-table is high, 2-10 feet, and in certain areas reaches the surface, making the land almost unfit for cultivation. The deteriorated area lies mostly on both sides of the Western Bein and near the bed of the river.

3. Clay loam This covers the northern half of the Phillaur, Dhak and Retli tracts of Nawanshahr, the eastern half of Phagwara, and Sirwal of Garhshanker tahsils. The soils are moderately fine-textured where clay and sand are in almost equal proportion. The soils become lighter from east to west: in

Nawanshahr it is largely a stiff loam or clay, in Phillaur, it is a firm loam, in Nakodar, to the east of Bein, the soil is rather reddish loam, and to the west of the Bein, sands predominate and even low sand-hills exist. In Garhshanker tahsil, the percentage of silt and clay is higher and therefore, the soils are stiff and hard to cultivate - though it has the characteristic of silt loam. It has a good water-holding capacity and is well-drained and consequently this part of the Doab is agriculturally important. Canal irrigation has helped a great deal to improve the soils. Wheat, sugarcane, cotton, maize, rice and pulses are the main crops and yields are high.

4. Sandy clay loam This is moderately fine-textured soil and covers Sirwal tracts of Dasuya and Hoshiarpur tahsils. The soil is relatively sandy but fertile. A variety of crops can be grown without irrigation as the soil is retentive of moisture. Wells are used more as an insurance against a long, continued drought, or to supply water to the most delicate crops and vegetables, which require water at regular intervals. While the quality of sub-soil is good, and the soil has a good texture, it has been greatly damaged by the sand brought by the rainy season torrents. Large areas are under choes, and reclamation of this land requires serious attention. Wheat, maize, millets, cotton and grams are the main crops of the region.

5. Sandy loam This covers the western half of Phagwara tahsil, Dona and Manjki of Nakodar tahsil, one third of Dona of Kapurthala and a small portion of Jullundur tahsil. It covers the area on both sides of the Eastern Bein. The soils are fertile and well drained. The soil responds well to crops such as wheat, maize, sugarcane and fodder crops. Rice is grown in a waterlogged area called Rohi. On both sides of the Eastern Bein, deterioration has taken place due to the presence of salts on the surface, giving a barren look with patchy

growth. The quality of the sub-soil water is good. Well irrigation is very common, and canal irrigation has recently been introduced in Nakodar and Phagwara tahsils.

II. Sandy soils

These soils are found in two different localities, that is, a belt parallel to the Siwalik in the east, running from north-west to south-east, and around Jullundur. The hilly soils in the east are coarse and relatively infertile, while the Jullundur tract exhibits the best soils of Bist Doab. The soils on the whole are coarse-textured, with the exception of Jullundur tract, which has more finely-grained soils than the eastern section. These soils are further sub-divided into three categories:

1. Loamy sand These cover the whole of Jullundur tahsil and Dona of Kapurthala tahsil. This tract lies between the Eastern Bein on the east, and the Western Bein on the west. Dona is a local name of the soil, and suggests that the soil is formed of two constituents - sand and clay - though in fact, sand now predominates and very little clay remains. These soils are well-drained, they are fertile and produce a large variety of cereals, vegetables and fruits. Wheat, cotton, sugarcane and rice are the major crops although groundnuts have gained importance during the last few years. Well irrigation is common, but recently canal irrigation has also been introduced in the southern parts of Jullundur tahsil.

2. Sand These cover Maira of Dasuya and Rakkar of Hoshiarpur and Garhshanker tahsils. Numerous choes which rise from the Katar Dhar deposit most of their load in this region, since the speed of the water is abruptly checked as they enter the plains here. The sand is coarse and has low water-holding capacity, resulting in rapid desiccation of the soil. In the northern part of Dasuya

tahsil, the soil is coarser and gravel concentrations are found. Rice and wheat are the major crops in Dasuya section, and wheat, maize and gram predominate elsewhere. Well irrigation is common on the whole, and canal irrigation is also practised in Dasuya.

3. Coarse sand These soils are found in the upper reaches of the choes, covering Kandi tracts of Hoshiarpur, Garhshanker, and Kandi and Rakkar of Dasuya tahsils. These soils are subject to excessive erosion owing to (a) loose rock structure (b) torrential nature of rainfall (c) lack of vegeation cover. The soil cover is thin and evanescent, and stony patches exist. The water-table is relatively low, 30-40 feet. Irrigation, both flow and lift, is difficult, if not impossible, due to topography and structure. The main source for growing crops is rainfall, 40-60 inches per year. Wheat, rice, maize and millets are the main crops.

III. Clayey soils

They cover a very insignificant portion of the region in the south-east - Bit-Manswal of Garhshanker tahsil. The clayey soils are fine-textured, but very hard and sticky, though not infertile. A local proverb explains the soil as '*Gilli Goha te Sukki Loha*', meaning that the soils are soft and yielding while wet, but very hard and sticky when dry. Rice and maize are the main crops. Cultivation is mainly dependent on rainfall, though in certain places, lift irrigation from small tanks is also practised.

SOIL PROBLEMS

The soils of Bist Doab pose three major problems. These are:

I. Soil erosion

II. Waterlogging (*Sem*) and salinity-alkalinity (*Thur*)

III. General flooding

These problems pose a serious threat to the agricultural economy and the general health of both people and livestock. The details of area suffering from these is given below (Table 4.3).

TABLE 4.3 AREA UNDER CHOES, SAND, THUR AND SEM, 1968-69

	Per cent of total cultivated area				
	choes	sand	thur	sem	total
Bist Doab	2.50	0.05	0.60	0.40	3.55
Punjab	0.77	0.01	1.19	0.27	2.24

Source: Statistical Abstract of Punjab, 1968-69

In Bist Doab, about 60,000 acres of land suffers from these problems. Out of this, the maximum area has been spoiled by choes, 71.5 per cent, followed by thur 17 per cent, sem 10 per cent and sand 1.5 per cent. In addition, a considerable area lies under water. To overcome these problems, immediate and energetic remedial and preventive measures are required.

I. Soil erosion

The effect of soil erosion is two-fold: soil removal and sand-spread.

> Losses of good land by erosion and sand-spreads have been very serious. Before British rule the Siwaliks had been under petty feudal lords and the forests were on the whole preserved for hunting; this society was largely broken up by the conquest, and legal titles were secured virtually by squatting. No control was exercised over land use, and at the same time the general economic development of the plains called for much constructional timber. The forests were gutted by reckless timber-felling, charcoal burning and all too intensive grazing of goats.
>
> (Spate and Learmonth, 1967: 539)

The result can be the total disappearance of vegetation. The combined effect of loose rock structure, lack of vegetation cover, and the torrential nature of rains, adding to the devastation of the soil on a large scale.

It was in 1878, that the problem of soil erosion was first realised by the Deputy Commissioner of Hoshiarpur district. The intensity and seriousness of the problem can easily be realised from the events which took place since then, and they were:

1878	(i) Visit of B.H. Baden-Powell, Conservator of Forests, Punjab
	(ii) Indian Forests Act was passed
1883	Appointment of E.McA. Moir (Deputy Conservator of Forests, N.W. Province)
1898	Sanction of Hoshiarpur Choes Bill, by the Government of India
1900	Hoshiarpur Choes Bill became law
1904	Afforestation work on the Siwalik started
1919	Detailed survey of the area by B.H. Wilsdon (1919)
1929	Appointment of Mr. Holland, as Deputy Conservator of Forests
1937	Appointment of Dr. R. Maclagan Gorrie, as a Forest Officer
1939	Constitution of a Special Soil Conservation Division
1945	Proposals made by the Forests Department in the Post-War Development Plan, Punjab, 1945

During the decade 1940-50, the efforts to check this menace were greatly hampered; first due to the Second World War and later due to unstable conditions prevailing in the country as a result of the 'Freedom Movement' followed by the Partition, in 1947.

After Independence, the subject of soil erosion was mainly the concern of the States. Realising the damage being caused by the menace, the Central Government of India established, in 1953, the Central Board of Soil Conservation to assist the States. Since then the work has been carried out by various departments, that is, Forestry; Irrigation; and Land, Reclamation

Irrigation and Power Research Institute (Amritsar). It was only in the late 1950's that some progress was made and some areas were again brought under economic cultivation. The work undertaken by the Land,Reclamation, Irrigation and Power Research Institute, Amritsar, has met with a large measure of success, but due to financial difficulties the area that might be reclaimed was limited.

The causes of the soil erosion were numerous and so are the solutions. A detailed account of soil and water conservation in Punjab (East and West) has been given by Gorrie (1938, 1946). The theory of soil and water conservation is well documented and need not be re-iterated here. For the last century, Bist Doab and many other parts of Punjab have faced the problem of soil erosion.

Water erosion is most serious in the hilly region of the Doab.

> Between Beas and Sutlej the Siwaliks are on the whole more sharply defined than they are to the west, and for climatic and historical reasons more deforested than they are to the east. The result has been erosion on a spectacular scale.
>
> (Spate, 1967: 535)

The erosion caused by fast-flowing <u>choes</u> in higher parts of the Katar Dhar in Hoshiarpur district is more widespread and the damage done to soils is extensive. These <u>choes</u> wash away the fertile top soil in the hills and deposit coarse sand on top of good soil in the lower areas. In Hoshiarpur district, 42,245 acres of land have been thus damaged by these <u>choes</u>, which is 7 per cent of the total cultivated area of the district.

Another kind of damage is identified on steep slopes by sheet erosion due to heavy rains. This results in what are locally known as <u>Darrar</u> lands (land spoiled due to deep-gully erosion).

In the plains, water erosion is confined to the valleys of the rivers

Beas and Sutlej and Eastern and Western Beins. Here the erosion is through: (a) bank erosion and (b) devastation by meandering and river avulsions. The fast-flowing Beas river frequently breaches its banks and as a result its left bank is badly cut up by spill channels. Here the land is eroded by over-flow and the top soil has been washed away. On both sides of the river Sutlej and Eastern Bein, a large area has been damaged in a similar fashion.

Wind erosion is not very significant in the hills, though it does exist. It is more prominent in Kapurthala and Jullundur districts, where it has damaged a considerable area. During the summer months, hot dry winds carry large amounts of sand from the dry open beds of the choes and rivers and spread them indiscriminately over the cultivated area. The details of the damaged area in each district of the Doab is given in Table 4.4.

TABLE 4.4 AREA UNDER CHOES, SAND, THUR AND SEM IN BIST DOAB (1968-69)
(in acres)

District	Choes	Sand	Thur	Sem
Kapurthala	-	875	4530	1025
Jullundur	-	-	5150	4810
Hoshiarpur	42245	-	260	110

Source: Statistical Abstract, Punjab, 1968-69

II. Waterlogging and salinity-alkalinity

Waterlogging and consequent salinity, has also damaged a large area of Punjab. In Bist Doab, however, they are confined to low-lying areas near the rivers - Beas and Sutlej - and around Western and Eastern Beins. Kapurthala and Jullundur districts are most affected with a loss of 2 per cent and 1.4 per cent of their cultivated area respectively. In Kapurthala alone, 129,300 acres (38.4

per cent) out of the total area (covered by the sample) of 336,700 acres have a high salt content at the surface , prohibiting economic cultivation (Uppal, 1964). Over a further 24,400 acres - 7.2 per cent of the total area covered by the sample - the salt has not yet risen to the surface, but with the rise of the water table and defective agri-irrigational practices, this too is liable to become thur (saline). A further 24,800 acres - 7.4 per cent - is highly alkaline, leaving only 158,200 acres - 47.0 per cent - fit for cultivation. In the Rohi area, near the Western Bein, and the low-lying area around Suchetgarh, deflocculation of the soil colloids due to high alkalinity has caused a break-down of the soil structure. The puddled condition of the soil retards percolation and impedes drainage, and even the penetration of roots is restricted. At a number of places on the Bholath side the corrosive action due to excessive alkalinity is seen on sugarcane, on the bark of the stem near the roots. The growth of the plants has further been checked due to increase in the wilting coefficient of the soil as a result of salt accumulation. Moreover, the soil becomes increasingly infertile due to the prevailing anaerobic conditions.

III. General flooding

Flooding is another common feature of the Doab. The region is surrounded on all sides by rivers and choes. During the rainy season, the rivers and choes spread over large areas - causing damage to crops, buildings, communication and life. This has led to the depopulation of large areas on the left and right banks of rivers Beas and Sutlej respectively (Fig. 7.1). Agriculture has also been abandoned in certain areas. The extent of abandonment may be assessed from the number of uninhabited villages in the affected areas (Table 4.5).

TABLE 4.5 NUMBER OF UNINHABITED VILLAGES IN BIST DOAB, 1961

Affected area	Total villages	Number of uninhabited villages	Percentage of uninhabited to total villages
Kapurthala tahsil	582	150	25.8
Nakodar tahsil	353	54	15.3
Phillaur tahsil	240	22	9.1
Nawanshahr tahsil	290	19	6.5
Dasuya tahsil	649	64	10.0
Garhshanker tahsil	496	34	7.0

Source: District Census Handbooks, 1961

SUMMARY

The soils of Bist Doab fall into three main categories: (i) loamy, (ii) sandy, and (iii) clayey. Loamy soils predominate and form the major part of the plains. Sandy soils comprise the hills. Generally, soils of the Doab are deficient in nitrogen, and have low to medium reserves of phosphorus and potassium. Soil erosion, waterlogging, salinity and flooding are the general soil problems. In the higher parts, excessive drainage, and in the lower parts, lack of drainage, have been responsible for converting fertile lands into barren lands, which need reclamation.

Historically, the study of Punjab soils has been primarily directed to single purpose applications, and little attention has been given to soil potentials on a comprehensive area-wide basis. The data on soil are thus limited. The soils of most of the Doab are fertile and have considerable potential for crop growing. In a few tracts, the soil has been damaged due to defective agri-irrigational practices. The soil management and conservation must, therefore, remain critical for stable and sustained agricultural growth.

CHAPTER 5

WATER RESOURCES

In Chapter 3, it was established that the rainfall is both inadequate and unreliable. The variability factor further reduces the effectiveness of rainfall. Hence it is necessary to explore other sources of water which could be made economically available for effective and assured supply of irrigation in the region. These sources might be either ground water or surface water. Here, an assessment is made of the former. This demands a thorough analysis of (i) the quality, (ii) the distribution and spatial changes, and (iii) the potentials of ground water resource. The aim of this chapter is to investigate these aspects which could help in the future agri-irrigational planning of the region. A detailed discussion of irrigation is presented later (Chapter 16).

THE QUALITY OF GROUND WATER

River water generally contains only a small percentage of dissolved salts, and thus the canal water derived from rivers, being low in salt content, is fit for irrigation (Eaton, 1950). It has been shown that continuous use of canal water does not cause any deterioration of the soil. Yet, where ground water is used or intended to be used for irrigation, it is necessary that the water should be analysed for its suitability.

In the Doab, about 1,000 water samples from different areas were analysed during the Soil and Ground-Water Surveys (1963-64) and the Geological and Geophysical Surveys (1964). The classification of samples according to their electrical conductivity, for all the three districts of the Doab, is given in Table 5.1.

TABLE 5.1 THE QUALITY OF SUBSOIL WATER, BIST DOAB

Electricity conductivity (micro mhos/cm) at 25°C	Percentage of total samples in each category				*Assessment for irrigation
	Kapurthala	Jullundur	Hoshiarpur	Bist Doab	
	(565)	(267)	(168)	(1,000)	
Below 250	1.4	2.9	3.6	2.2	Entirely safe
250 - 750	88.3	73.3	85.7	84.2	Practically safe
750 - 2,250	10.3	23.1	10.7	13.6	Safe for permeable soils and moderate leaching
More than 2,250	-	0.7	-	0.7	Unsafe

Figures in brackets denote total samples analysed
*Based on Punjab Agricultural University, Ludhiana

It is evident from this that the subsoil water is generally low in salts and may safely be used for irrigation. Only in small isolated pockets it is excessively saline.

SPATIAL DISTRIBUTION AND CHANGES IN WATER-TABLE

Distribution

Figures 5.1 and 5.2 show the depths of subsoil water for pre-monsoon (June) and post-monsoon (October) periods for the years 1951 and 1968 respectively. From the examination of these figures, the following observations can be made:

In 1951 (i) The average depth of water ranged between less than 10 feet in the

Beas Bet to more than 50 feet in the Katar Dhar and Sutlej Bet regions.

(ii) The water-table had a definite trend - it tended to fall from west to east.

(iii) The seasonal fluctuations, from pre-monsoon to post-monsoon, were confined largely to eastern and south-eastern areas. The Beas and central zones did not exhibit seasonal fluctuation.

In 1968 (i) The average depth of water ranged between 10 and 40 feet over the region, suggesting a rise of the water-table over most of the Doab.

(ii) The direction of the flow of water seems to have been confused if not reversed. It bore no similarity to that of 1951.

(iii) The seasonal fluctuations were more conspicuous in 1968 than in 1951, confirming that there is a relationship between the rise of the water-table and the amount of rainfall.

On the whole, the subsoil water is available between 10 and 40 feet below the natural surface of the Doab (except the hilly region in the north-east). Personal observations suggest that the depth of water in this hilly part is found to be as low as 100 feet. The absence of data does not allow confirmation of this point. The availability of water at a depth, such as in the case of the Doab, obviously suggests that it can be most economically exploited and used for irrigation. The conditions are most suitable for well and tube-well irrigation in the region.

Changes

In the Doab, the regular observation of subsoil water-table began in 1926-27. Between 1927 and 1941, the water-table fell by about 5 feet throughout the region. This fall has been attributed mainly to (a) the intensity of well irrigation and the consequent decrease in fallow acreage and (b) below average rainfall during the period (Cotter, 1931; Uppal, 1965). After 1941, the region experienced a significant rise of water level. It has been estimated that during the decade 1944-1954, the water-table rose by about 10 feet on average - a rise due to excessive rainfall during the period (Bhardwaj, 1956). Since then, the water-table has been rising in the region, except in unirrigated and partially well-irrigated areas. In the canal-irrigated tract, the water-table has risen greatly after the construction of the Bist Doab Canal in 1955.

During the 28 year period 1941-1968, subsoil water-depth observations, both for June and October levels, were made in about 170 wells and pipes scattered over the canal-irrigated tract (Land Reclamation, Irrigation and Power Research Institute, Amritsar). Together with rainfall data for the corresponding years these observations have been mapped and analysed. The long-term changes (1941-1968) are shown in Figure 5.3. It is evident from Figure 5.3 that the water-table has risen throughout during this period, though the rise is most conspicuous in the canal-irrigated zone of Jullundur district. The maximum rise of 20-30 feet occurred in and around Jullundur tahsil, around Garhdiwala in Hoshiarpur tahsil and on the east of Garhshanker town in Garhshanker tahsil. Over most of the region, the water-table rose between 10 and 20 feet. In the Beas zone, however, the rise of the water-table was only 5 feet. No significant fall occurred during this period, in the Doab.

The changes which took place during the last decade, 1958-1968, are considered separately and are mapped in Figure 5.4. This decade is significant because it coincides with the introduction of canal irrigation in the region. During this decade, the water-table rose on an average by about 10 feet only in the canal-irrigated regions. The water-table in the rest of the region, which is partially irrigated by wells or is unirrigated, has undergone a fall of up to 5 feet. In a few isolated pockets, in Hoshiarpur district, the fall has been even more than 5 feet.

The above analysis of Figures 5.3 and 5.4 suggests that:

(a) The water-table, during the period under review, has exhibited an overall tendency to rise.

(b) The rise of the water-table from June to October is apparent, suggesting that there is a relationship between rise or fall of the water-table from June (pre-monsoon) to October (post-monsoon) and rainfall from June to September.

(c) The introduction of canals has probably encouraged a rise of the water-table.

In the following pages these suggestions are tested statistically. To allow a detailed examination of these points, the region has been divided into five zones (Fig. 5.5), - the basis for division being the drainage pattern, possible sources of recharge and discharge, and soil texture. The five zones are:

(i) Sutlej Zone

(ii) Beas Zone

(iii) Central Zone

(iv) Canal Zone

(v) Katar Dhar Zone

The general tendency of the water-table to rise is evident from the preceding analysis. The trend of water-depths to fall (or the water-table to rise) has been further investigated by fitting in regression lines between average subsoil water-depths and the corresponding years. The regression lines obtained have negative slopes indicating the rise of the water-table during the period 1941-1968 (Fig. 5.5).

The average rate of rise of the water-table per year, the correlation coefficients between the values of average subsoil water-depths and the corresponding years, in respect of each zone, are given in Table 5.2.

TABLE 5.2 RISE OF WATER-TABLE IN DIFFERENT ZONES OF BIST DOAB, 1941-68

Zone	Average rise of water-table per year (feet)	Correlation coefficients	Level of significance
Sutlej Zone	0.7362	-0.9778	P<.001
Beas Zone	0.1514	-0.7372	P<.001
Central Zone	0.6539	-0.9097	P<.001
Canal Zone	0.9351	-0.9749	P<.001
Katar Dhar Zone	0.7868	-0.9499	P<.001
BIST DOAB (as a whole)	0.5091	-0.9477	P<.001

Effect of rainfall on the rise of water-table

The relationship between the water-table, from June to October, and the total rainfall, from June to September, may be studied by fitting in regression lines for each zone from 1949 to 1968 (20 years). The regression lines have positive slopes (Fig. 5.6). The regression coefficients with their standard errors, of all the zones, are given in Table 5.3. From this table it is clear that the regression is not significant in the case of Sutlej Zone, while in Katar Dhar it approaches a level of significance. In all other zones, it is significant.

Correlation coefficients have also been worked out between these two variables and are given in Table 5.4. These correlation coefficients are significant, with the exception of the Sutlej Zone and Katar Dhar Zone. In

TABLE 5.3 REGRESSION OF RAINFALL ON RISE OF WATER-TABLE IN BIST DOAB

Zone	Regression coefficients	Standard error	Level of significance
Sutlej Zone	0.0286	±0.0739	P>0.50
Beas Zone	0.1332	±0.0492	P<0.025
Central Zone	0.1830	±0.0453	P<0.001
Canal Zone	0.2274	±0.0869	P<0.025
Katar Dhar Zone	0.1433	±0.1019	P<0.20
BIST DOAB (as a whole)	0.1816	-0.0734	P<0.025

these two zones, the correlations and regressions are not significant (though they may suggest a positive trend), because of some other factors affecting the water-table. In the Katar Dhar, fast flowing rainy torrents (choes) drain the rainy water so quickly that there is no time for the water to percolate into the ground. Hence a major portion of the rain water, which would normally have added to the subsoil water is drained off to the surrounding areas in the form of run-off. This water floods the lower reaches of these choes and hence adds to the subsoil there. This is clear from the fact that most of these choes disappear after flowing a short distance in the plains. They do not fall into any regular drainage channel of the region (Fig. 2.4).

In the Sutlej Zone, however, the flow of the river has been reduced considerably with the completion of the Bhakra Dam in 1963. This dam has resulted in the lowering of the general level of the river, since the river is acting as an agent of discharge, while it used to act as an agent of recharge before the completion of the Bhakra Dam. Hence the water-table has not risen to the extent it might have, had the flow of the river not been

TABLE 5.4 CORRELATION OF RAINFALL WITH RISE OF WATER-TABLE IN BIST DOAB

Zone	Correlation coefficients	Level of significance
Sutlej Zone	0.0911	P>0.50
Beas Zone	0.5377	P<0.05
Central Zone	0.6897	P<0.001
Canal Zone	0.5249	P<0.05
Katar Dhar Zone	0.3147	P>0.05
BIST DOAB (as a whole)	0.5065	P<0.05

regulated. The intensity of floods has also reduced considerably.

It can be inferred that there is a positive relationship between the rise of the water-table, from June to October, and the amount of rainfall, from June to September.

Effect of canal irrigation on rise of water-table

The effect of canal irrigation on the rise of the water-table has been studied by many. These studies have shown that canal irrigation has caused a rise of water-table in most parts of Punjab, as well as elsewhere in northern India (Bhardwaj, 1956; Mehta, 1957, 1965; Uppal, 1966; Singh et al., 1967). It has also been found that no significant seepage is occurring along the lined canals, whereas it did occur along unlined canals (Singh et al., 1967).

It has been established earlier, that the water-table has risen considerably in the canal-irrigated zone. To investigate the effect of canal irrigation on the rise of the water-table, the data has been divided up into two parts, that relating to the pre-canal period (1941-1954) and that relating to the post-canal period (1955-1968). The trend of the water-table to rise has been investigated by fitting regression lines between average subsoil water-depths and the corresponding years, for both pre-canal and post-canal periods separately. The negative slopes of regression lines in both cases confirm that the water-table has risen, though the rates differ significantly ($P<0.05$). It is higher in the pre-canal period, 0.80 feet, and lower in the post-canal period, 0.55 feet, per year. However, reference to the mean values, 25.8 feet of the last year of the pre-canal and the first year of the post-canal, 20.8 feet periods, indicates that significant rise, 5 feet occurred immediately after the introduction of the canals. Moreover, this rise has occurred despite the fact that well and tube-well irrigation has increased by about 30 per cent from 1954 to 1968 (Fig. 5.7), in the canal-irrigated area. The analysis of variance in both pre-canal and post-canal periods is given in Table 5.5. Both the regressions are highly significant.

TABLE 5.5 ANALYSIS OF VARIATION

Pre-canal period					Post-canal period				
Source of variation in June to October change in water-table	Sum of squares	Degree of freedom	Mean squares	F	Source of variation in June to October change in water-table	Sum of squares	Degree of freedom	Mean squares	F
Regression	147.68	1	147.68	98.85*	Regression	70.334	1	70.334	44.43*
Residual	17.93	12	1.494		Residual	19.00	12	1.583	
Total	165.61	13			Total	89.34	13		

* $P<.01$

The residual sum of squares in the pre-canal period is only 10.8 per cent, whereas in the post-canal period it is as much as 21.3 per cent. This shows that variation in the rise of the water-table between June and October, in the post-canal period, is due to some other factor than rainfall and points to the introduction of canals as the major determining factor.

THE QUANTITY OF GROUND-WATER

In the preceding discussion, it has been observed that the ground-water conditions are favourable and the water can be most economically exploited and used for irrigated farming. It has also been concluded that there is a general tendency for the water-table to rise over most of the region. In some areas canals are contributing to considerable rises of the water-table, through seepage. The geographic implications, therefore, lead to the conclusion that there is a strong case for the utilisation of ground-water in the wake of (i) the existing emergent demand for more water for irrigated farming, and (ii) to arrest further rises in the water-table which could lead to deterioration of soils. In the following pages, however, an assessment is made of the potentials of ground-water resource.

Sources of recharge

The addition of water to the zone of saturation in an aquifer is called ground-water recharge. The term recharge, here, has been used to mean all water received in the area, whether or not it reaches the zone of saturation. The principle source of recharge in the Doab, as elsewhere in Punjab, is infiltration from rainfall. Seepage from rivers, dams, irrigation channels and irrigated fields, and the subsoil inflow from surrounding areas are secondary sources.

Rainfall In order to estimate the total water received from rainfall, data on rainfall and surface run-off at the outfall of the Eastern and Western Beins, the major drainage channels of the region, were collected. The water retained from rainfall (rainfall - run-off) was taken as recharge, and is given in Table 5.6.

TABLE 5.6 RECHARGE FROM RAINFALL TO SUBSOIL WATER IN EAST AND WEST BEINS CATCHMENT AREAS, 1964–68

	East Bein (Catchment area 590,000 acres)				West Bein (Catchment area 535,000 acres)			
Year	Average rainfall (inches)	Run-off (June to September) Acre feet	Inches	Recharge in Inches	Average rainfall (inches)	Run-off (June to September) Acre feet	Inches	Recharge in Inches
1964	30.95	258,125	5.25	23.70	29.10	189,479	4.25	24.85
1965	20.30	110,625	2.25	18.05	20.90	124,833	2.80	18.10
1966	32.38	309,750	6.30	26.08	37.45	338,833	7.60	29.85
1967	27.60	201,583	4.10	23.50	27.25	173,875	3.90	23.35
1968	29.60	177,000	3.60	26.00	29.50	169,416	3.80	25.70
Mean	28.16	211,416	4.30	23.86	28.84	199,288	4.47	24.37

Source: Land Reclamation, Irrigation and Power Research Institute, Amritsar.

From Table 5.6, total recharge figures may be deduced as 23.86 and 24.37 inches, in case of the Eastern and Western Beins catchment areas respectively. The average of these, 24.12 inches, can be applied to the whole region, thus

$$\frac{2.25 \text{ million acres} \times 24.12 \text{ inches}}{12} = 4.52 \text{ million acre feet}$$

Canals Bist Doab and Shah Nahr are the two canal systems supplying surface water to the Doab. The water supplied to Bist Doab in 1968, from both these canals was 500,000 acre feet - the details are given as follows:

Water supplied and used in Bist Doab in 1968 (acre feet)

Shah Nahr canal	Bist Doab canal	Total
213,000	287,000	500,000

Rivers The region has two major rivers, the Sutlej and the Beas. Eastern and Western Beins are the other two seasonal drainage channels, in addition to numerous choes. To assess recharge from these rivers is not possible here, due to lack of suitable data. However, the water level observations taken during the last decade indicate that the Beas river, in its lower reaches, serves as a source of recharge of subsoil water. This recharge is limited only to the rainy season, when some areas in the vicinity of Kapurthala and Dasuya tahsils are flooded, and the general level of the water of the river is much higher than the subsoil water level of the surrounding areas. No significant underground flow is occurring from the Sutlej river at present.

For lack of data, no assessment can be made about the recharge from Eastern and Western Beins and other choes in the region, although they constantly add to the subsoil water, especially those choes which do not drain their water into any regular drainage channel.

Sources of discharge

The subsoil water which leaves the area is called discharge. Evapotranspiration, withdrawals by wells and tube-wells, and subsoil outflow to rivers, drains and to the surrounding areas, are the main sources of discharge.

Evapotranspiration An average rate of evapotranspiration for Punjab, has been estimated to be 2.30 acre feet per irrigated acre and 2.25 acre feet per unirrigated and uncultivated acre (Land Reclamation, Irrigation and Power Research Institute, Amritsar, Punjab). Adopting the same, the total loss of water, due to evapotranspiration will be:

(i) Loss of water at the rate of 2.25 acre feet for 2.25 million acres (total area of the Doab) = 5.06 million acre feet

(ii) Additional loss from irrigated area

$$\frac{\text{Additional loss from irrigated area}}{0.80 \text{ million acres (net area irrigated)}} = 5.46 \text{ million acre feet}$$

Withdrawals by wells, tube-wells, etc. Although the data are generally inadequate, it may be estimated that about 2.3 million acre feet of ground-water was pumped out by 56,653 wells and tube-wells operating in the Doab, in 1967-68. Since rainfall in this year was near average, this can be taken as a normal withdrawal of ground-water through this source. The figure deduced above has been calculated from the equation given below, and the relevant data are given in Table 5.7.

$$\text{Annual water pumped (acre feet)} = \frac{\text{Annual average working hours} \times \text{Average depth of irrigation (feet)} \times \text{Number of wells/tube-wells}}{\text{Time taken per irrigation per acre (hours)}}$$

TABLE 5.7 AVERAGE WORKING HOURS, DEPTH OF IRRIGATION AND TIME TAKEN PER IRRIGATION BY WELLS AND TUBE-WELLS

Source	Annual average working hours	Average depth of irrigation (feet)	Time taken per irrigation per acre
Tube-wells (3 x 3 inches)	3,500	0.189	4.5 hours
Wells (Persian wheels)	1,504	0.125	15 hours

Source: The Board of Economic Enquiry, Punjab: 1954

Subsoil outflow into rivers, drains and surrounding areas There are no suitable data available to indicate how much subsoil water is drained into rivers, drains and the areas surrounding this tract. It has been observed that the rivers serve as agents of discharge of subsoil water, as the subsoil water level, in areas close to rivers, is higher than the general level of the rivers (Singh, 1970, Uppal, 1962). This discharge has been estimated to be in the order of 1 million acre feet, in the whole of Punjab (Singh, 1970). A major portion of this could be allocated to Bist Doab, as Beas and Sutlej are the major rivers of Punjab and drain mostly Bist Doab.

It is not possible to estimate the loss of subsoil water to surrounding areas, though personal observations confirm that the drains do serve as agents of discharge of subsoil water. They have lowered the water-table in certain areas, particularly where drains have been constructed to remove excess water.

In conclusion, it is evident that total discharge exceeds total recharge insignificantly (0.44 million acre feet), and hence it can be inferred that an approximate equilibrium is attained in the region, as a whole. The data are summarised in Table 5.8.

TABLE 5.8 RECHARGE AND DISCHARGE OF SUBSOIL WATER IN BIST DOAB

Recharge		Discharge	
Source	Acre feet (in millions)	Source	Acre feet (in millions)
Rainfall	4.52	Evapotranspiration	5.46
Canals	0.50	Wells and tube-wells	2.30
Wells and tube-wells	2.30	Others	1.00
Others	1.00		
Total recharge =	8.32	Total discharge =	8.76

Storage capacity

The storage capacity of the ground-water reservoir can be defined as the quantity of water that the substrata can release by gravity for pumping.

This depends upon the geological formation and texture of the substrata. Fine materials such as clay, silt, etc. release less water, whereas coarse materials such as sand, gravel, etc. release larger quantities of water. Moreover, the flow of the subsoil water is significantly affected by the pressure of the subterranean ridge called the Burrard of Delhi-Shahpur Ridge (Fig. 2.1). The ridge is formed of metamorphic and igneous rocks, which are impervious and obstruct the westward flow of the underground water, from the Doab plains towards Rajasthan.

TABLE 5.9 STORAGE CAPACITY OF GROUND-WATER RESERVOIR, BIST DOAB

Depth zone	Total area (million acres)	Thickness of strata (feet)	Volume of material (million acre feet) column 2 x column 3	Average specific yield (per cent)	Volume of water (million acre feet) column 4 x column 5/100
1	2	3	4	5	6
25 to 50	2.25	25	56.25	11.8	6.60
50 to 100	2.25	50	112.50	11.8	13.20
100 to 300	2.25	200	450.00	15.2	68.40
				Total =	88.20

Usable quantity of ground-water

From Table 5.9, it is evident that 88 million acre feet of ground-water are available up to 300 feet below the natural surface although all this quantity cannot be utilized. The water-table can be depressed up to a reasonable limit, say 30 to 40 feet depth below the natural surface. Further lowering will make the pumping uneconomical. At present, the average water-table in Bist Doab lies at about 15 feet and, assuming this as the limit of depth of the water-table, the usable water from 15 to 40 feet, may be calculated at 6.60 million acre feet. This water can be used directly for irrigation by pumping, since its quality has been observed to be fit for irrigation.

With the depletion of underground reservoir, by pumping and subsequent lowering of the water-table, the slope of the subsoil water will be reserved and the outflow of ground-water will cease and the rate of evapotranspiration will fall. Both these factors will provide a good quantity of water annually, and this quantity of additional water will thus be available for utilisation. Excluding the subsoil water presently withdrawn by wells and tube-wells, about 4 to 5 million acre feet of subsoil water is thus available for irrigation in the Doab.

THE SURFACE WATER

Bist Doab has an advantageous position as regards the availability of surface water. The region is surrounded by two rivers, Sutlej and Beas, and although some limitations are posed by seasonal variations in flow, large amounts of water are available for irrigation. The rivers have a period of reduced flow from mid-November to mid-February. The subsequent rise is relatively slow until April, on the Sutlej, and the end of June, on the Beas. The peaks are reached between mid-July and mid-August and the subsequent fall is relatively sharp. The annual flow of both rivers at the places where they emerge from the foothills (Mandi Plain for the Beas, and Rupar for the Sutlej), and the seasonal variations are shown in Table 5.10.

The seasonal variations, though following the same general pattern, differ considerably in magnitude and time. Apart from the seasonal variations,

TABLE 5.10 SEASONAL VARIATIONS IN THE FLOW OF THE BEAS AND SUTLEJ

Name of river	Annual mean flow (million cubic metres)	Percentage of mean annual flow during April to June	July to September	October to December	January to March
Beas	15665.20	15	67	10	8
Sutlej	16775.33	23	62	9	6

Source: After N. D. Gulhati, 1968, p. 352

the annual volume of flow also fluctuates from year to year. Inspite of these limitations, a considerable amount of surface water is utilised for irrigation in different parts of Punjab. In the Doab, the use of surface water is limited and confined to parts of Dasuya, Garhshanker, Nawanshahr, Nakodar and Jullundur tahsils. The significance of the use of surface water in the total irrigation of the region may be ascertained from Table 5.11.

TABLE 5.11 NET AREA IRRIGATED AS PERCENTAGE OF NET SOWN AREA BY DIFFERENT SOURCES, 1967-68

District	Wells/tube-wells	Canals	Others	Total
Kapurthala	61.9	3.9	-	65.8
Jullundur	61.3	8.3	0.4	70.0
Hoshiarpur	11.7	5.7	0.2	17.6
BIST DOAB	43.4	6.5	0.2	50.1

From Table 5.11, it is clear that the canals contribute a very small percentage of the net irrigated area, in comparison to wells and tube-wells. The use of canal water has been limited mainly because:

(a) well irrigation is easy and cheap

(b) canal irrigation in the region is of recent introduction.

Further expansion of canal irrigation is possible, but it must be adopted with care, in view of a consequential rise of the water-table and subsequent waterlogging due to seepage.

SUMMARY

The variability, unreliability and inadequacy of rainfall makes it critically essential to explore the feasibilities of the use of ground and surface water. The subsoil water in the Doab, exists under water-table conditions and is largely available between 10 and 40 feet below the natural surface. In the hilly region, the water-table tends to be as low as 100 feet. The subsoil water has undergone many changes during the period under review. It has risen considerably over most of the Doab, though most conspicuously in the canal-irrigated tract. Linear regression analyses indicate significant correlation between: (i) rise of water-table and rainfall, and (ii) rise of water-table and introduction of canals.

The quality of ground water is good and can safely be used for irrigation. About 4-5 million acre feet of additional water is estimated to be available for economic use under the present technological levels. In addition, a substantial amount of surface water is available. This can be easily exploited and used provided necessary steps are taken to control the seepage leading to waterlogging. The hilly parts impose problems in water resource development, and, therefore, improvements are likely to be limited in the near future. Elsewhere, throughout Punjab, water resources are abundant and are being exploited and used on a large scale.

PART III

THE HUMAN, SOCIAL AND ECONOMIC ENVIRONMENT

The study of processes of development has found a limited place in geographic literature in the past (Gilbert, 1971) and often the studies of economic development were viewed differently by geographers and economists. While geographers have tended to emphasize the role of physical environment (Munton, 1969), economists on the other hand, have laid more emphasis on economic factors in conditioning the distribution of geographic phenomena, 'whereby the mutual relationships between the phenomena have been under-emphasized' (Chisholm, 1966: 24). The increasing appreciation by geographers and economists of the fact that social factors influence economic development and that the spur to economic growth must be sought in the social attitudes of the community, is partly due to the work done by sociologists in the past decade or so. This less rigid and often more profitable approach can be found in recent studies, such as those by Schultz (1965), Chisholm (1966), de Wilde (1967), Dumont and Rosier (1970), Myrdal (1968, 1971), Hunter (1969, 1970), Hodder (1971), Logan (1972) and various United Nations reports, which have emphasized the role of human and social factors in the development process.

The human stock is the fundamental economic resource. Capital, technology, natural resources are of course important, but they cannot develop by themselves. It is only through the application of human knowledge, skill and initiative can anything be made of them. It is thus the human resource, the people of the country, on which development ultimately depends. The example of Europeans who colonised North and South America, in the past, is a fine one of the human achievement of a very high order. In recent times, remarkable achievements of Israelis, Mexicans, Danish, Taiwanese, Greeks, Japanese, Chinese (in Hong Kong, etc.) and Europeans (in south-east Asia and Africa) are some other fine examples.

In this part, consideration is given to the human, social and economic environment as it exists and affects the processes of transformation in the Doab. It examines and analyses the quantitative aspect of population - the number, the size of holdings, the system of land tenure, the pressure of livestock - which largely influence the decisions and the response to innovations, and also to account for the qualitative aspect of the people, which governs its capacities and capabilities in exploiting the available resources to its advantage. This, the human, social and economic environment, is divided into two chapters. The first deals with the human element and its role in agriculture and the second analyses the socio-economic landscape in which the human element operates.

CHAPTER 6

THE HUMAN ELEMENT IN AGRICULTURE

The role of human and social factors in agriculture is very important in the case of the tropical world, where economic development largely implies agricultural development. Even then, and unfortunately so, most of the studies of tropical agriculture begin with the classification of the land use or the subsistence nature of tropical agriculture, instead of with the farmer himself (Morgan, 1969), who, in fact, is the 'prime mover' in any development process.

A thorough understanding of an agricultural system - especially one which has "built-in resisters" to change - implies an understanding of the system through the eyes of the farmer. It is not the '...objective, physical, operational environment which is significant so much as the perceptual environment - that personal interpretation of reality specific to each individual' (Pigram, 1972: 132). Indeed 'so pervasive is culture in fixing people's perceptions and manipulation of natural phenomena that different populations, though occupying the same habitat, may have literally different resources' (Firey, 1960).

The results of the planned development in most of the developing countries indicate that indigenous populations vary in their receptivity of modern techniques. This variance is finally reflected in uneven development. Those who responded favourably to new innovations have improved their lot, while those who resisted are still struggling with the problems of food shortages and malnutrition. For example, Kenya has progressed at a much faster rate than

Tanzania, though both started with the planned development at the same time. The Kikuyu farmer of Nyeri district of Kenya is more progressive than the Sukuma farmer of Tanzania. Equally striking is the contrast between the farming systems of European settlers and those of the indigenous inhabitants amongst whom they settled, as in parts of Africa and New Guinea. Thus differences in performance are not merely between different countries, or between different areas of the same country, but also between different communities inhabiting the same region. The experience of the past two decades suggests that the failure in achieving the desired results in agricultural development are

> ...largely traceable to inadequate knowledge or insufficient appreciation of the relevance of all the socio-economic factors that determine the proper approach to the farmer and that condition the farmer's responses and receptivity to change.
>
> (de Wilde, 1967: 45)

Like many other developing countries, India has had a planned development during the last 25 years. The results achieved by different regions in the country, in the field of agriculture, showed marked variance as is clear from Tables 6.1 and 6.2. Thus 'We have on the one hand, the *wirtschaftwunder* of the Punjab; on the other the alarming examples of Assam, Uttar Pradesh [eastern] and West Bengal...' (Chaudhuri, 1971: 52). Not only this, for there are, indeed, many instances where one community has progressed further than others in the same environment. For example, Jats in Punjab, Sadgops in West Bengal, Reddies in Andhra Pradesh and Patidars in Gujrat. Again, the Gounder farmers of Coimbatore exhibit a greater response and higher achievements in increasing production than the Mirasdars of Tanjore, though the latter are better placed in terms of physical resources. This proves that

TABLE 6.1 STATE-WISE GROWTH RATES OF PRODUCTION, AREA AND YIELD, 1952-53 TO 1964-65 (IN TERMS OF AVERAGE 1952-3 TO 1954-5 = 100

	Foodgrains (per cent)			Non-foodgrains (per cent)		
State	Production	Area	Yield	Production	Area	Yield
Punjab*	4.30	1.63	2.26	9.46	4.90	3.03
Andhra Pradesh	3.65	0.84	2.63	1.83	-1.59	3.93
Assam	0.80	1.36	-0.48	1.62	1.21	0.35
Bihar	3.28	0.64	2.55	2.61	1.84	0.78
Gujrat	2.09	-2.19	5.34	8.03	5.93	1.64
Himachal Pradesh	4.23	0.63	3.40	1.63	3.27	-1.30
Kerala	4.37	0.51	3.74	1.83	2.06	-0.20
Madhya Pradesh	2.58	1.28	1.16	4.50	1.67	2.44
Madras	4.89	0.75	3.92	4.96	2.45	2.05
Maharashtra	2.29	0.33	1.94	5.15	0.83	3.65
Mysore	3.71	0.91	2.64	4.91	0.59	4.03
Orissa	2.60	0.79	1.75	3.40	1.65	1.54
Rajasthan	2.68	3.03	-0.23	4.89	5.13	-0.09
Uttar Pradesh	0.91	0.40	0.49	4.28	2.19	1.72
West Bengal	1.16	0.26	0.90	4.23	4.29	0.09
All India	2.75	1.02	1.60	4.79	2.56	1.79

Source: India Ministry of Food and Agriculture (1968), Tables 12, 13 and 15.
See also Table II in Minhas and Vaidyanathan (1965)

* Punjab before Reorganisation of 1966

> Apart from those elements of the plan which Government itself can control, the achievement of final results depends on the voluntary, unplannable choices and activities of millions of individual farmers.
>
> (Hunter, 1970: 62)

The human element has played a major role in the development of agriculture in Punjab (Nair, 1961; Hunter, 1969; Randhawa, 1970; Krishnan, 1971). To understand it fully one has to see this in the context of recent history. However, two initial points may be made. First, this summary account relates to Punjab as a whole (Bist Doab forms a part of it). Secondly, the population characteristics described here largely represent the Sikhs, who comprise a large percentage of the farmers in Punjab. Indeed, the Sikhs constitute 63 per cent of the total rural population of Punjab (1961 census) and are likely to constitute an even larger percentage of the population engaged in farming.

Prior to the partition of the Indian sub-continent, though the composite unit of Punjab ranked top in terms of foodgrains production, the eastern Punjab (now the Indian Punjab) had for many years been deficient in food. Just before the partition in 1947, the food deficiency was about 35,000 tons (Nair, 1961: 114). As a result of the partition, the food situation was further aggravated in two ways. First, general food shortage was visited on India, since most of the surplus food-growing areas were transferred to Pakistan. Secondly, millions of people became destitute refugees as a result of the transfer of population. Out of the estimated 5 millions (Dey, 1969: 4) who fled from West Pakistan to India, 2.5 millions (Krishnan, 1971) were Sikhs, most of whom were settled in Punjab. According to the 1951 census, 2,731,929 immigrants from Pakistan settled in Punjab, out of which 1,276,827 (46.7 per cent) were agriculturalists.

TABLE 6.2 PER CAPITA INCOME IN VARIOUS STATES OF INDIA AT CURRENT PRICES, 1955-56 TO 1967-68 (RUPEES)

State	*1955-56	1960-61	1965-66	1966-67	1967-68
Punjab	277	382	610	751	828
Andhra Pradesh	229	284	393	449	-
Assam	268	311	418	500	556
Bihar	149	203	-	-	-
Gujrat	270	339	417	468	-
Haryana	-	359	437	589	678
Himachal Pradesh	-	298	250	476	-
Kerala	228	276	-	-	-
Madhya Pradesh	216	288	350	397	508
Madras	230	335	437	503	-
Maharashtra	287	392	392	-	-
Mysore	203	290	-	-	-
Orissa	187	249	-	-	-
Rajasthan	232	318	381	453	499
Uttar Pradesh	178	246	364	-	-
West Bengal	295	319	404	436	536
India	255	307	421	471	543

Source: Statistical Abstract of Punjab, 1969

*Inter-District and Inter-State Income Differentials - 1955-56 Occasional Paper No. 6, N.C.A.E.R., 1963

It might not be out of place to mention that this significant progress was achieved in the face of many stresses and strains - internal as well as external - at different times. The two wars with Pakistan (1965 and 1971), which adversely affected the economy of the state in many ways, are obvious examples. From the stage of 'deficiency' around 1947 to that of 'self-sufficiency' in 1956-57 and finally to that of 'surplus' in 1966-67 is an achievement in which the Punjabi farmer can take a lot of pride and which he richly deserves.

The role that the human element has played in the agricultural development of Punjab can be further substantiated if comparison of the growth of Punjab is made with that of another region which has similar physical environment but a different type of community - eastern Uttar Pradesh. Both have peasant societies and have relatively high pressure of population. There was no significant difference in the industrial base between these two regions at the time of the partition of the country. Whereas eastern Uttar Pradesh had sugar mills, Punjab had textile mills. There was no heavy industry in either of them. Both these parts were much more backward than their western counterparts.

Since the partition, there has been a marked improvement in agriculture in Punjab while the performance of eastern Uttar Pradesh has been rather dismal. For instance, the foodgrain production in Punjab during the second Five-Year Plan was 58 per cent higher than in the first Five-Year Plan. In eastern Uttar Pradesh, on the other hand, it was only 0.1 per cent higher. The corresponding increase in the production of all agricultural commodities was 65 per cent in Punjab, but only 4 per cent in eastern Uttar Pradesh.

It may also be pointed out here that the efforts made by the government for agricultural development had not been so different in these two areas as to explain such marked differences in agricultural growth. This contrast in the performance of these two regions can therefore only be explained in terms of the role the human element plays in agricultural development.

What makes the Punjabi farmer behave differently from the rest of the farmers in the country? The answer seems to lie largely in his past history. Punjab has borne the brunt, and the first impact, of almost all major invasions by the foreign invaders since the 14th. century, as this was the traditional route of entry into the Indian sub-continent. The first invasion was that by Timur in 1398. This was later followed by many others. The Punjabis developed a frontier consciousness, looking with apprehension towards the mountain passes through which every few years came death and destruction. The region of chronic turbulence achieved some stability with the establishment of the Sikh rule under Maharaja Ranjit Singh (1780-1839). Even this could not give prolonged peace, as soon after the death of Maharaja Ranjit Singh his successors started fighting against each other for the throne. Finally Punjab was annexed to British India in 1841. Despite the richness of the soil and the abundance of harvests, there was never any prolonged prosperity nor ever any promise of long life.

In 1947, as a result of the partition of the country, a large number of refugees had to flee from West Pakistan to this state. This displacement faced them with a new challenge but they responded to it in a manner which was a 'practical demonstration of Toynbee's well-known thesis of challenge and response' (Sen, 1966: 12). After the partition, temporary dislocations from the border areas of Punjab continued, on account of the hostilities with Pakistan. The result has been that the Punjabis have 'developed an unusual capacity for adjustment to change, which makes them one of the least "rooted" communities in India, mentally, culturally and physically' (Nair, 1961: 112). The Punjabi has consequently become very industrious. He has greater mobility and enterprise and does not feel severely tied down to old dogmas. Nair (1961: 112) summarises the result thus:

> As an instrument of change in patterns of human behaviour the power of pure reason by itself is perhaps rarely effective. In the Punjab, certainly, more than reason or persuasion compulsions of history, and especially the recent partition of the State, seem to have played a vital role in weakening traditional trammels and taboos, especially those which restrict the choice and nature of a man's work.

The relevant characteristics of the Punjabi farmer may be enumerated as follows:

Industriousness Punjab has the 'sturdiest peasantry in India' and 'there is no more enterprising peasant than the Jat, who is the backbone of both districts'[Jullundur and Hoshiarpur] (Darling, 1947: 41, 43). The Punjab farmer is generally hard working, persevering and enterprising. There is a common saying in Punjab: dab ke wah, te raj ke khah, which translated means that labour hard in the field and eat to your complete satisfaction.

Progressiveness The Punjabi farmer has a progressive outlook. He is innovative and responds to the need for irrigation. It is here that the dynamism of the Punjabi farmer comes as a great asset. It is through his remarkable skill and will for accepting new innovations that

> In less than a generation he has made the wilderness blossom like a rose[in the canal colonies of West Punjab, now Pakistan] . It is as if the energy of the virgin soil of the *Bar* had passed into his veins and made him almost a part of the forces of nature which he has conquered.
>
> (Darling, 1947: 117)

Professional competence The Punjabi farmer is 'traditionally agriculturalist'. He accepts farming as his profession, his way of life, and consequently he lives with it. He has inherited a respect for agriculture, and even if he is reduced to the status of tenant or landless labourer, he generally practices a husbandry superior to that of the non-working castes of landowners, such as Brahmins, Banias, etc.; this inspite of the fact that the latter may have more capital, land, education, and thus superior means to acquire modern techniques and tools of cultivation. The Punjabi farmer generally has passed on to him a fund of farming experience of which he can make use and which he can supplement with the technical advances of his own generation. It is this experience which has equipped him with the ecological knowledge and understanding of farming techniques, and made him 'most vigorous and innovative' (John, 1969: 9). The agricultural experience of the Punjabi people is often further enriched by the fact that many gained, or have made, many opportunites to go abroad.

Mobility Contrary to the general rule of immobility of the Indian population, the people of Punjab have been mobile. Impelled by the economic conditions at home and lured by rich opportunities elsewhere, they have not only moved to other parts of India, but have also emigrated abroad. The three major periods of their out-migration from Punjab were:

(i) Pre-Partition (1882-1930)

(ii) Partition (1947-1950)

(iii) Post-Partition (1951 onwards)

During the pre-Partition period there were simultaneously two waves of out-migration. One was associated with the opening of the new canal colonies such as Lower Chenab Colony (1892), Lower Jhelum Colony (1902), Lower Bari Doab Colony (1917), both now in West Pakistan, and Gang Canal Colony (1927) in Rajasthan (India). The other wave of emigration was to foreign countries such as Burma, Malaya, Hong Kong, Fiji Islands and Australia, in the south-east, and east African countries, to the west.

Partition created conditions for mass migration of Hindus and Sikhs from West Pakistan to Punjab. Though most settled in Punjab, some moved to other border areas of Punjab, such as Karnal and Hissar districts in Haryana, the Tarai and the western districts of Uttar Pradesh, and Alwar, Bharatpur and Ganganagar in Rajasthan.

In the post-Partition period, most of the people who migrated from Punjab were the people from the flood-affected areas of Jullundur, Hoshiarpur, Kapurthala (which form Bist Doab) and Amritsar districts. Most of them went to the areas close to the borders of Punjab, where the irrigation facilities were newly extended or new lands were brought under cultivation. During this period, Punjabis also migrated to foreign countries, such as the United Kingdom, Canada and east African countries, in large numbers. This was possible only, as the immigration rules in Commonwealth countries were liberal and encouraged Commonwealth citizens to settle in these countries. Unfortunately no statistics are available as to how many people from Punjab have migrated to other parts of the country and to countries outside India. However, their major concentrations are found to be, the border areas of Punjab and big cities - Delhi, Calcutta, Bombay, Kanpur in India, and the United Kingdom, Canada and east African countries, outside India. According to an estimation of the Institute of Race Relations (1968) there were about 230,000 Indians living in Britain, three-quarters of them were Punjabis (Desai, 1963). The Bist Doab provided the 'bulk of the immigrants to Britain' (John, 1969: 13)

Moving away from their homes helped them in gaining experiences in many other trades and thus earning more money, which they could invest in land back home. This investment was generally in the form of buying more land, improving the land - by installing the tube-wells for irrigation, and buying agricultural machinery such as tractors.

> As a result, Sikhs are usually exposed to modern values and foreign ways, in larger numbers than their Hindu neighbors, and are a major source for promoting change when they return to their villages.
>
> (Frankel, 1971: 19)

<u>Flexibility</u> Inspite of a long tradition of farming, Punjabis do not feel tied down to that profession only, or for that matter any other particular profession. If it suits them, they would willingly switch over to other professions, as they did when they emigrated elsewhere. For example, most of the Punjabi immigrants in Britain, are factory workers, in Canada, lumbermen, in Califonia, U.S.A., horticulturalists and in South-East Asia, businessmen. At home, in cities they worked as taxi drivers, transporters and businessmen. Nair (1961: 105) sums it up well:

> It is this attitude among the masses of the Punjab which allows for greater economic flexibility and vocational mobility than the established orthodox social system within an Indian village generally permits.

SUMMARY

The appreciation and understanding of the human element is very important in the study of any development process - especially in the development of agriculture in the traditional societies of the developing world. Any development how well planned it might be, will be limited in its achievements, unless the farmer himself forms a part of the planning process and he participates in it. The lessons of the last 25 years of planning in India sufficiently substantiate this point.

Though geographers have avoided analysis of the behavioural environment in the past, yet, recently from the studies of environmental perception, a revived interest has emerged in geographic research concerned with behaviour in space (Koroscil, 1971). The author in this account has attempted to raise this point in its real perspective.

CHAPTER 7

THE SOCIO-ECONOMIC LANDSCAPE

The role of human element in agriculture has been discussed in the preceding chapter. This chapter describes and analyses the relevant social and economic factors which influence the decisions made by farmers and the receptivity of farmers to innovations. These factors are: the density of population, the size of work force, the size of holdings, the system of land tenure and, finally, the role of livestock in agriculture. It is suggested that these factors affect, first, the nature, intensity and direction of the processes of agricultural development and, secondly, the appeal and practicability of innovations in agriculture.

RURAL POPULATION

According to the 1961 census, the total population of Bist Doab was 2.4 millions in an area of 3,517 square miles, which gave a density of 695 persons per square mile - higher than the state average of 565. The bulk of the population was classified as rural, 78.6 per cent as against 76.9 per cent in Punjab as a whole. The ratio of males to females was almost the same as for Punjab, 47:53. However, the rate of literacy was found to be higher in the Doab (31.6 per cent) than in Punjab (26.7). Forty out of every hundred males, and twenty out of every hundred females, were literate.

The present discussion is mainly centred on the rural population as a social and economic variable. This is so because, firstly, the present study is mainly concerned with the changing patterns of cropland use and subsequently connected largely with the village population, whose livelihood is largely dependent on agriculture. Secondly, it constitutes a much larger proportion of the total population - 80 per cent. Moreover, as far as areal distributions are concerned, the rural population presents a more accurate representation of the situation.

The general distribution map of rural population (Fig. 7.1) has been constructed by using enumerations at village level for the year 1961. The urban population is superimosed on the map with shaded circles which illustrate the location of urban nucleations. The remainder of the figures are computer maps and have been prepared by grouping 3,669 villages of the Doab into 750 zones, each zone representing 4-5 villages. The grouping of villages was inevitable considering the time factor involved and the limitations of computer graphics. However, it is suggested that this grouping in no way affects the synoptic distribution.

Spatial distribution Bist Doab is predominately rural. In 1951, 78.8 per cent and in 1961, 78.6 per cent of the population was classified as rural. Though there was no significant percentile change in the rural population of the Doab during the decade, yet the absolute increase over the decade was about 227,700. The average percentile figure of the rural population of the Doab is little higher than the state average of 76.9 per cent (1961). Yet among the nine tahsils of the Doab, the population ranges from 97.9 to 49.5 (Table 7.1). These figures exhibit such a wide departure from the state as well as the Doab averages as to be genuinely exceptional. There are two tahsils, Jullundur and Phagwara, which have recorded a negative departure of 27.4 and 11.2 respectively from the state average. The remaining tahsils recorded positive departures - the maximum of 21.0 in Garhshanker and the minimum of 2.8 in

TABLE 7.1 RURAL POPULATION IN BIST DOAB, 1951-61

Region	Percentage of total population 1951	1961	Per cent variation 1951-1961	Departure of population (1961) from Bist Doab	from Punjab
Dasuya	88.0	90.2	+2.2	+11.6	+13.3
Garhshanker tahsil	97.2	97.9	+0.7	+19.3	+21.0
Hoshiarpur tahsil	78.8	79.7	+0.9	+ 1.1	+ 2.8
District average	88.0	89.2	+1.2	+10.6	+12.3
Jullundur tahsil	52.6	49.5	-3.1	-29.1	-27.4
Nakodar tahsil	93.0	92.1	-0.9	+13.5	+15.2
Nawanshahr tahsil	86.8	87.5	+0.7	+ 8.9	+10.6
Phillaur tahsil	82.9	92.3	+9.4	+13.7	+15.4
District average	72.1	71.5	-0.6	- 7.1	- 5.4
Kapurthala tahsil	81.4	82.3	+0.9	+ 3.7	+ 5.4
Phagwara tahsil	70.4	65.7	-4.7	-12.9	-11.2
District average	78.2	77.0	-1.2	- 1.6	+ 0.3
Bist Doab	78.8	78.5	-0.3	-	+ 1.66
Punjab		76.9	-	-	-

Source: Statistical Abstract of Punjab, 1968

District Census Handbooks Nos. 9, 10 and 15 (1961)

Hoshiarpur - both in the same district. The other areas where appreciable positive departures are found are Phillaur and Nakodar tahsils (over 15).

Yet the synoptic distribution of rural population in the Doab remained almost unchanged between 1951 and 1961. It is broadly distributed with respect to the quality of agricultural land, availability of water and the distribution of industrial concentrations. The major concentrations are easily distinguished around urban centres - especially around Jullundur City, Jullundur Cantonment, Phagwara, Hoshiarpur and Banga. Almost as important as these concentrations themselves, are the areas devoid of any settled population (Fig. 7.1). These are the areas on the periphery of the Doab, coinciding with the flood-affected areas in the west and south, and with that of rugged releif and thin soils of the hills in the east. This correlation between settlement and the physical environment is illustrated in Figure 2.2 and Figure 7.1.

Density Though the average rural density of the Doab is 556 persons per square mile - higher than the state average of 446 - it can fall to 376, as in Kapurthala tahsil, and rise to 772, as in Jullundur tahsil, showing a variation of as much as ± 30-40 per cent (Table 7.2). From Table 7.2, it is evident that Jullundur district is more densely populated than the others, while Kapurthala is more sparsely populated. These aggregate population figures, however, mask a high degree of variability in its spatial distribution. It is evident from Figure 7.2 that five distinct categories of rural population density exist (Table 7.3). These are discussed in the following pages.

1. Exceptionally high and very high densities These densities occur mainly in two areas. First, around the major urban centres and in those areas easily accessible to them and secondly, around the canal-irrigated parts of the Doab. Elsewhere, they are found in scattered patches, which are the results of a shift of population, either from areas liable to flooding (for example

TABLE 7.2 POPULATION DENSITY IN BIST DOAB, 1961

Region	Area (square miles)		Population		Persons per square mile	
	Total	Rural	Total	Rural	Overall	Rural
Dasuya tahsil	501.50	494.85	284,379	256,599	567	519
Garhshanker tahsil	506.40	505.90	287,605	281,629	568	557
Hoshiarpur tahsil	523.70	519.34	300,610	239,780	574	462
District total	1,531.60	1,520.09	872,594	778,008	570	512
Jullundur tahsil	389.40	363.94	567,742	280,794	1,458	772
Nakodar tahsil	364.40	363.31	182,908	168,456	502	464
Nawanshahr tahsil	299.30	295.63	244,419	213,794	817	723
Phillaur tahsil	289.10	286.71	232,298	214,335	804	748
District total	1,342.20	1,309.59	1,227,367	877,379	915	670
Kapurthala tahsil	525.40	510.20	232,958	191,668	443	376
Phagwara tahsil	117.60	113.60	110,820	72,891	942	642
District total	643.00	623.80	343,778	264,559	535	424
Bist Doab	3,516.80	3,453.48	2,443,739	1,919,946	695	556
Punjab	19,450.20	19,207.20	11,135,069	8,567,763	572	446

Source: District Census Handbooks Nos. 9, 10 and 15 (1961)

Statistical Abstract of Punjab, 1968

the Kapurthala, Nakodar and Phillaur tahsils) or from less fertile agricultural areas to those capable of supporting intensive cultivation (for example in Hoshiarpur district). High densities are also found in the region of commercial farming around the suburbs of Jullundur and in the northern parts of Nakodar and Phillaur.

2. High densities The triangular area, running parallel to the boundaries of the Doab, and lying between 750 feet and 1,000 feet contours (except the Bet areas on the margins of the Doab) supports high densities. This triangle has its apex in the north and base in the south. These areas are irrigated and are almost free from waterlogging, soil erosion and flooding. These factors, in addition to the adequate communications provided by the two main roads and two railway lines, have contributed to the system of diversified commercial farming, which extends over more than half of the Doab.

TABLE 7.3 RURAL POPULATION DENSITY, 1961

Category	Density per square mile	Frequency of occurrence		Per cent of total occurrences
1. Exceptionally high to very high densities	Over 1,500 1,000-1,500	11 78	89	11.87
2. High densities	500-1,000		388	51.73
3. Medium densities	250-500		182	24.27
4. Low densities.	Below 250		72	9.60
5. Virtually uninhabited	-		19	2.53

3.Medium densities The areas of medium density occur largely to the south-west of the 750 feet contour, almost coinciding with the tracts of marsh and flood plain. The whole of Kapurthala tahsil, east of the Dhussi Bund and large parts of Nakodar tahsil, support medium densities, due in part to lack of industrial development. Elsewhere, medium densities are found only in scattered and small areas.

4. Low densities The north-eastern hilly parts - largely Kandi tracts of Hoshiarpur, Dasuya and Garhshanker tahsils - support low densities. This region is mostly eroded and infested by choes. Thin and stony soils, lack of water for irrigation during dry months and excess of it during wet months, offer little for agriculture. Communications are difficult due to steep slopes.

5. Virtually uninhabited A ribbon-shaped region on the southern and western periphery of the Doab has been abandoned by population and is virtually uninhabited. This is the 'hazardous zone', where frequent flooding is a continuous risk to the property and life of the farmer. Though these areas are productive ecologically and could produce good crops, the risks are so great that the farmer is not willing to risk his limited resources. These 'weaker areas' demand greater attention from the farmer, the planner and the government.

In conclusion, the distribution and density of rural population is largely a product of land capability and the extent to which it has been exploited. Once the population has established its distribution pattern, this is bound to have its impact on the cropping pattern and the intensity of cropping according to the requirements of the people who inhabit the area. Industrial development, though of late origin, has also begun its impact in re-shaping the existing distribution pattern of the Doab. The impact is clearly visible around industrial towns such as Jullundur and Phagwara.

RURAL LABOUR FORCE

The age and sex composition of the population are two important indicators which determine the size of the labour force. According to the 1961 census, 41.8 per cent of the total population of the Doab was below the age of fifteen and was thus mostly dependent. Only 28.9 per cent of the population of the Doab was regarded as 'economically active', and the corresponding figure for Punjab as a whole was 31.1. The bulk of this labour force - 91.6 per cent was male. The female labour constituted only 8.4 per cent - a little higher than the Punjab figure of 8.1 per cent - of the total labour force.

Of the total labour force, 49.5 per cent is engaged in agriculture, much less than Punjab State where it is 55.9 per cent. The cultivators share most of it, 43.3 per cent (Punjab 46.2 per cent), leaving only 6.2 per cent for the outside or hired labour (Punjab 9.6 per cent). The percentile sex composition of the rural workers shows insignificant departure from that of the overall composition, as is evident from Table 7.4. However, the population engaged in agriculture in the rural Doab is 12 per cent higher than that of the overall figure.

Agricultural labour force

The agricultural labour force constitutes 61.5 per cent of the 'economically active' population, of which 53.9 per cent are cultivators and the remaining 7.6 per cent agricultural labourers or hired labour. These figures vary over the districts of the Doab, according to the level of industrialisation and agricultural specialisation.

From the study of Tables 7.4 and 7.5, the following points emerge:

(i) The rate of overall literacy in all categories of workers is low (30 per cent). It is lower in the case of cultivators (26 per cent), and is lower still among hired labour (12 per cent) - thus exhibiting the correlation between agricultural status and levels of literacy.

(ii) The participation of the female population in any economic

TABLE 7.4 COMPOSITION OF RURAL LABOUR FORCE, 1961

Region	Details	All workers			
		Total	Male	Female	Per cent of total population
Hoshiarpur	Total	230,878 (100)	200,854 (87.0)	30,024 (13.0)	29.7
	Literate	71,440 (30.9)	68,910	2,530	
	Illiterate	159,438 (69.1)	131,944	27,494	
Jullundur	Total	249,176 (100)	231,915 (93.1)	17,261 (6.9)	28.4
	Literate	77,547 (31.1)	74,860	2,687	
	Illiterate	171,629 (68.9)	157,055	14,574	
Kapurthala	Total	76,713 (100)	73,281 (95.5)	3,432 (4.5)	29.0
	Literate	22,632 (29.5)	22,057	575	
	Illiterate	54,081 (70.5)	51,224	2,857	
Bist Doab	Total	556,767 (100)	506,050 (90.9)	50,717 (9.1)	29.0
	Literate	171,619 (30.8)	165,827	5,792	
	Illiterate	385,148 (69.2)	340,223	44,925	

Figures in brackets indicate percentages

Source: District Census Handbooks Nos. 9, 10 and 15 (1961)

TABLE 7.5 COMPOSITION OF AGRICULTURAL LABOUR FORCE, 1961

Region	Details	Cultivators Total	Male	Female	Per cent of total workers	Agricultural labourers Total	Male	Female	Per cent of total workers
	Total	132,803 (100)	116,806 (88.0)	15,997 (12.0)	57.5	11,801 (100)	11,497 (97.4)	304 (2.6)	5.1
Hoshiarpur	Literate	37,181 (28.0)	36,240	941		1,815 (15.4)	1,812	3	
	Illiterate	95,622 (72.0)	80,566	15,056		9,989 (84.6)	9,687	301	
	Total	119,674 (100)	114,552 (95.7)	5,122 (4.3)	48.0	25,648 (100)	25,284 (98.6)	364 (1.4)	10.3
Jullundur	Literate	30,593 (25.5)	30,017	576		2,948 (11.5)	2,937	11	
	Illiterate	89,081 (74.5)	84,535	4,546		22,700 (88.5)	22,347	353	
	Total	47,430 (100)	46,262 (97.5)	1,168 (2.5)	61.8	4,626 (100)	4,555 (98.5)	71 (1.5)	6.0
Kapurthala	Literate	11,848 (25.0)	11,652	196		363 (7.8)	362	1	
	Illiterate	35,582 (75.0)	34,610	972		4,263 (92.2)	4,193	70	
	Total	299,907 (100)	277,620 (92.6)	22,287 (7.4)	53.9	42,075 (100)	41,338 (98.2)	739 (1.8)	7.6
Bist Doab	Literate	79,622 (26.5)	77,909	1,713		5,126 (12.2)	5,111	15	
	Illiterate	220,285 (73.5)	199,711	20,574		36,952 (87.8)	36,227	724	

Figures in brackets indicate percentages.

Source: District Census Handbooks, Nos. 9,10 and 15 (1961) activity is small (9.1 per cent). It is still smaller in the case of cultivators (7.4 per cent), and is the smallest among agricultural labourers (1.8 per cent). This suggests that family taboos and social prejudices continue to play a major role in deterring the female population from seeking gainful employment.

(iii) Though the rate of literacy among all categories of workers does not show any significant regional variation from that of the average Bist Doab, yet it is the female participation which varies appreciably. It is high in Hoshiarpur but low in Kapurthala, particularly in the case of total workers as well as cultivators.

Since the participation of female workers in agricultural activity is minimal, this aspect of population will not be considered in detail.

Spatial distribution The spatial distribution of workers engaged in agriculture is shown in Figure 7.3. Three broad categories emerge (Table 7.6).

TABLE 7.6 WORKERS ENGAGED IN AGRICULTURE, 1961

Category	Per cent of agricultural workers to total workers	Frequency of occurrence	Per cent of total occurrences
1. Very high - high	Over 80 60-80	112 349 = 461	61.47
2. Medium	40-60	227	30.27
3. Low/no population	20-40	43 19 = 62	8.26

The uninhabited category has already been discussed and it is not considered in the subsequent discussion

1. High to very high concentration of agricultural workers The Kapurthala, Dasuya, southern Garhshanker, Bet areas of Nakodar, Phillaur and

Nawanshahr tahsils (with the exception of the suburbs of urban centres) exhibit a high concentration of agricultural workers. These are the areas which are devoid of significant industrial development and where there is little scope for employment outside agriculture.

2. Medium concentration of agricultural workers Most of Jullundur district, Phagwara, Hoshiarpur and northern most parts of Garhshanker tahsils (with the exception of the suburbs of urban centres) support a medium concentration of agricultural workers. In these areas there are opportunites of employment in industry, commerce and other development projects.

3. Low concentration of agricultural workers The pressure of agricultural workers on land is low in the suburbs of urban centres due, first to increased opportunities of employment in the cities and towns and secondly, to increased mechanisation of agriculture near these urban centres.

Hired labour

Agriculture in India is a family affair. The proportion of hired labour in the total work force is small in the Doab - 7.6 per cent. In the agricultural work force, every eighth worker is a hired labourer. The share of hired labour is more in Jullundur district (10.3 per cent) and is less in Kapurthala and Hoshiarpur districts (6.0 and 5.1 per cent). This variation is due to the fact that Jullundur district comprises the commercial cropping belt, while Kapurthala and Hoshiarpur are largely areas of subsistence farming.

Spatial distribution From Figure 7.4, it is clear that the canal-irrigated tract has the highest concentration of hired labour while the rest of the Doab has low dependence on hired labour. In certain parts of Kandi of Hoshiarpur tahsil, it is almost negligible. However, there are three clearly recognizable categories of hired labour distribution (Table 7.7).

TABLE 7.7 SHARE OF HIRED LABOUR IN AGRICULTURE, 1961

Category	Per cent of hired labour to total agricultural labour	Frequency of occurrence		Per cent of total occurrences
1. Significant	20-40 40-60	15 131	146	19.47
2. Low	10-20	220		29.33
3. Nominal	5-10 Below 5	145 220	365	48.67
Virtually uninhabited	-		19	2.53

1. Significant share of hired labour The district of Jullundur has a high proportion of hired labour. This characteristic is also associated with canal irrigation, where intensive cultivation is practised, and with suburban areas where vegetable and dairy farming has grown in response to an urban market.

2. Low share of hired labour This occurs where commercial agriculture decreases in intensity particularly with increasing distance from urban centres.

3. Nominal share of hired labour The region of subsistence farming (Kapurthala tahsil and the whole of Hoshiarpur district) supports a few hired labourers. Most of the agricultural operations are carried out by the family itself and only casual hired labour is employed.

From a comparative study of Figures 7.2, 7.3, and 7.4, the following points emerge:

(i) Areas with exceptionally high densities of rural population generally exhibit a low percentage of agricultural workers but a high proportion of hired labour, a product of specialised farming and a consequence of absentee landlordism.

(ii) Areas with high or very high densities of rural population support low percentages of agricultural workers but high percentages of hired labour, a product of intensive irrigated farming of foodgrains.

(iii) Areas with medium densities have a high percentage of workers engaged in agriculture but a low ratio of hired labour to agricultural labour, a product of subsistence foodgrains farming.

(iv) Areas with low densities exhibit low percentages of both agricultural workers and hired labour.

In conclusion, the agricultural labour force is a product of firstly, the type of farming and the level of technological advance in agriculture, and, secondly, the nature and intensity of cropping. Whereas the introduction of machines reduces the labour force engaged in agriculture, the introduction of truck and dairy farming creates more work for the people, as in the case of suburban areas of the Doab.

SYSTEM OF LAND TENURE

The first decade of Independence brought significant legal changes in the system of land tenure in Punjab (as well as in India). Prior to the introduction of land reforms, the _Ryotwari_ system of land tenure was largely prevalent in Punjab. A few tracts, however, were under _Jagirs_. Under the _Ryotwari_ system, the land owner might cultivate his land himself, have it cultivated by servants or by tenants, or might sell it. The most prevalent form of rent was a pre-determined portion of the produce raised by the tenant, known as _batai_.

With the introduction of various reforms, this system was largely abolished. The Punjab Abolition of _Ala-Malkiat_ and _Talukdari_ Rights Act, 1953, resulted in the abolition of intermediaries. With the introduction of The Punjab Occupancy Tenants Act, 1952, the class of tenants with the right of occupancy became proprietors. Moreover, The Punjab Security of Land Tenures Act, 1953, ensured legislative protection to the tenants. The first legislation, enacted in 1950, placed a ceiling on land holdings at 100 acres, which was later amended to 30 standard acres.

On the implementation of these reforms, there had been divergent viewpoints. However, the general feeling undoubtedly is that the provisions relating to land reforms are not being implemented properly: rather the 'provisions about security were implemented by their violation' (Konar, 1969: 7). Yet, while there have been many errors and ommissions in implementing the legislation, there has been a distinct reduction in the area under tenancy (infra p. 325).

A three-tiered structure characterises present land tenure organisation. This comprises peasant proprietors, owner-cum-tenants and tenants with varying degree of security, but often with none. Peasant proprietorship dominates the agricultural scene in Punjab with more than 50 per cent of the farmers being owner-cultivators. Another 34 per cent are owner-cum-tenant cultivators (who partly own and partly rent land). This brings the percentage of total peasant cultivators to 84. This figure is higher still in the case of Bist Doab. The tenants constitute only 14 per cent of the total number of farmers. This figure may be underestimated since many of the tenant-cultivated fields are deliberately recorded as cultivated by the owner through agricultural labourers. The law is thus evaded through a variety of informal crop-sharing arrangements.

The agrarian structure is most favourable for agricultural transformation in Punjab, as the peasant owner is the predominant element in the agrarian structure. It is this institutional structure which gives the State an advantage over others where institutional bottle-necks such as high proportion of tenancy inhibits the adoption of a modern farming system.

The mode of land tenure is individual peasant farming. An element of collectivity has survived chiefly in the form of common grazing lands of the village, known as shamlat (common land). There has been a growing demand for the change of use of these lands from mere grazing to cultivation. The situation is rapidly changing and in most of the villages, largely for socio-economic reasons, these lands have been brought under cultivation. The revenue procured by letting or leasing the common lands is mainly retained as a community's amenity fund by the elected headman of the village, called Surpanch. This fund, with the consensus of the members of the Punchayat, is utilised for the general benefit of the people. The main items of expenditure are the construction of link roads, school buildings, the construction of pacca streets, and maintenance and installation of street lights, play-grounds and water arrangements.

The co-operative farms are rare; and most of these have been organised only to evade the impact of land reform. The production of State owned land is also insignificant and is mostly in the form of State Seed Farms or Military Farms.

While the owner has the right to sell, mortgage, lease or let his land as and when he desires, the tenant on the other hand does not enjoy any such right. So much so, that he cannot even sub-let any portion of the land he has rented to a friend or relation. Since his tenure is in most cases insecure, it is scarcely worth his while to think of undertaking any long-term improvement such as investment in irrigation, or even short-term investment in fertilizers.

For the landless labourer, there is even less reason to raise his efficiency.

Area cultivated by owners

The percentage of area under owner cultivation is high in most of the Doab, reflecting the predominance of owner-cultivation (Fig. 7.5). From Figure 7.5 three broad categories emerge (Table 7.8).

TABLE 7.8 OWNER CULTIVATION AS A PERCENTAGE OF CULTIVATED AREA IN BIST DOAB, 1965-66

Category	Per cent of cultivated area		Frequency of occurrence	Per cent of total occurrences
1. Very high	More than 75		181	50.3
2. High	50 - 75		119	33.0
3. Moderate	25 - 50	33	60	16.7
	Less than 25	27		

The highest concentration (over 75 per cent) of owner cultivation is in the new canal-irrigated tract and well-irrigated parts of Jullundur, Hoshiarpur, Dasuya, Garhshanker, Kapurthala and Phagwara tahsils. In the hilly tract (rain-fed) of Hoshiarpur district and ill-drained soils of Kapurthala and Phillaur tahsils, the proportion of area cultivated by owners is moderate, that is less than 50 per cent. Elsewhere it ranges between 50 and 75 per cent and is found in scattered localities.

Area cultivated by share croppers

The area under lease is insignificant. Most of the area which is not cultivated by owners themselves, is cultivated by the share croppers. The share cropper rents the land from the owner on batai (share in the produce) and these rents are generally very high. The share cropper is normally required to pay half of the total produce, though the rent fixed by legislation is one third. Moreover, the tenant is to share the cost of seed, fertilizer (if he uses it at all, willingly or unwillingly), hired labour (occasionally), water rate and fuel expenses (where irrigation is by oil-operated pumping set or tube-well). It may be pointed out here that the landholder does not share either the cost of agricultural implements required for everyday operations, nor the maintenance of the draught force.

With the growth of population and lack of alternative employment, the bargaining position of the share cropper, or for that matter landless agricultural labourer, has weakened considerably, though due to the social structure it was never strong. His social position has sunk still further, as farms have been getting much smaller. The high prices of agricultural land created a steep threshold over which few tenants were able to climb in order to become landholders themselves, if they wanted to.

Despite all this, the land owner would prefer to keep his tenants on a year to year basis, possibly shifting them from one piece of land to another, ensuring that the tenants cannot acquire any continuing rights to a given piece of land. Indeed, in many cases, the land owner would have an arrangement with the revenue officials to ensure that the entries in the official records are in his favour.

The land cultivated by share croppers belongs partly to the absentee land owners - persons who are either employed in other pursuits, such as the army, police or other civil offices (in case of the Doab, employment in the army is relatively important) - and partly to those landholders who cannot cultivate the whole of their holdings themselves or those who do not wish to do so on account of their social status. Since, in a peasant society, ownership of land is the only real and permanent security of life (in the absence of any security offered by the state), all wish to own a parcel of land. The ownership of the land carries a social status, which few could afford to lose. Moreover, the farmer's prestige and his status are accorded to the number of acres he owns.

The distribution of the area cultivated by share croppers is shown in Figure 7.6. The results of an analysis of the data are presented in Table 7.9.

TABLE 7.9 CULTIVATION BY SHARE CROPPERS AS A PERCENT OF CULTIVATED AREA IN BIST DOAB, 1965-66

Category	Per cent of cultivated area	Frequency of occurrence	Per cent of total occurrences
1. High	60-80 40-60	66	18.3
2. Moderate	20-40	124	34.4
3. Low	Less than 20	170	47.3

Size of holdings

Due to high pressure of population on land and long established cultivation in the region, Bist Doab is predominately an area of small and medium sized farms. Of the total households, 55.1 per cent are of the size ranging between five and fifteen acres. The corresponding figure for the state as a whole is 41.3 (Table 7.10). The farms with less than five acres and more than fifteen acres, share almost the same percentage (over 20 per cent). In Punjab, on the other hand, large farms with over fifteen acres constitute 41.2 per cent of the total. Moreover, the larger farms (over 50 acres) are almost negligible in the Doab (0.9 per cent), while they form 2.5 per cent of the total households in Punjab.

Two points may be made here. First, that subsequent to the partition of the country in 1947, the new settlers in the region were largely small landholders in Pakistan. Their holdings were further reduced by the graded cut

Secondly, the small farms are largely the result of the sub-division of agricultural land, primarily the result of existing laws of inheritance. Although, according to the provisions in the Hindu Succession Act, 1956, the female heirs could share the ancestral property - which would further result in reducing the size of holdings - it has not, however, yet had as significant effect in Punjab. In most of the cases the female heirs would voluntarily surrender their share in favour of their male heirs, if any, to protect the traditional sanctity of relationship and honour of the family.

TABLE 7.10 SIZE OF CULTIVATING HOUSEHOLDS IN BIST DOAB, 1961
(Based on 20 per cent sample)

	Size of holdings (in acres)						
Region	All sizes	Below 2.5	2.5-4.9	5.0-9.9	10.0-14.9	15.0-29.9	Above 30
Bist Doab	29,648	2,706 (9.1)	3,885 (13.1)	10,195 (34.4)	6,249 (21.1)	5,225 (17.6)	1,222 (4.1)
Punjab	145,663	9,747 (6.7)	14,842 (10.2)	39,380 (27.0)	20,788 (14.3)	46,225 (31.7)	13,882 (9.5)

Figures in brackets indicate percentage of the total sample households.
Unspecified farms are not included.

Source: Statistical Abstract of Punjab, 1969

Details of different size of holdings in the different tahsils of the Doab are presented in Table 7.11, and their further breakdown by categories in each size are plotted in Figure 7.7. From an analysis of Table 7.11 and Figure 7.7, the following points can be made:

(i) Over most of the Doab, more than 15 per cent of the holdings are smaller than five acres. Garhshanker and Dasuya tahsils have predominately smaller farms, where about one third of the farms are below five acres.

TABLE 7.11 PERCENTAGE AND SIZE OF CULTIVATING HOUSEHOLDS IN BIST DOAB (RURAL), 1961

(Based on 20 per cent samples)

Region	Size of holdings in acres					
	Below 2.5	2.5-4.9	5.0-9.9	10.0-14.9	15.0-29.9	Above 30
Dasuya tahsil	856 (16.5)	815 (15.7)	1,736 (33.5)	902 (17.4)	664 (12.8)	178 (3.4)
Garhshanker tahsil	975 (17.4)	1,040 (18.5)	1,924 (34.3)	955 (17.0)	612 (10.9)	96 (1.7)
Hoshiarpur tahsil	389 (10.8)	475 (13.2)	1,215 (33.8)	694 (19.3)	624 (17.4)	173 (4.8)
Hoshiarpur district (average)	2,220 (15.4)	2,330 (16.2)	4,875 (33.7)	2,551 (17.9)	1,900 (13.2)	447 (3.1)
Jullundur tahsil	179 (5.4)	307 (9.2)	1,034 (31.0)	798 (23.9)	764 (22.9)	205 (6.1)
Nakodar tahsil	92 (3.8)	188 (7.8)	695 (29.0)	602 (25.1)	667 (27.8)	149 (6.2)
Nawanshahr tahsil	184 (6.2)	354 (12.0)	1,171 (39.6)	700 (23.7)	465 (15.7)	72 (2.4)
Phillaur tahsil	121 (4.9)	257 (10.4)	837 (33.7)	614 (24.8)	538 (21.7)	97 (3.9)
Jullundur district (average)	576 (5.2)	1,106 (9.9)	3,737 (33.4)	2,714 (24.3)	2,434 (21.8)	523 (4.7)
Kapurthala tahsil	169 (4.4)	449 (11.6)	1,442 (37.3)	899 (23.3)	725 (18.8)	164 (4.2)
Phagwara tahsil	50 (5.2)	103 (10.7)	333 (34.7)	216 (22.5)	202 (21.0)	45 (4.7)
Kapurthala district (average)	219 (4.5)	552 (11.4)	1,775 (36.8)	1,115 (23.1)	927 (19.2)	209 (4.3)
Bist Doab average	3,015 (9.9)	3,988 (13.1)	10,387 (34.2)	6,380 (21.0)	5,261 (17.3)	1,179 (3.9)

Figures in brackets indicate percentage of the total sample households
Unspecified holdings are not included

Source: Census of India, 1961. Volume XIII, Punjab, Part III; Household Economic Tables, p. 15, 16 and 19

(ii) Nakodar and Jullundur have, on the other hand, larger farms, of over fifteen acres constituting 34.0 and 29.0 per cent respectively. At the same time, they have a smaller proportion of farms less than five acres (11.6 and 14.6 per cent).

(iii) In most of the cases, more than 50 per cent of the farms are smaller than ten acres. Only about 25 per cent of the farms are of fifteen acres or more.

(iv) The farms with 5.0-9.9 acres predominate over the whole region and constitute over one-third of the total households.

(v) The small farms (less than five acres) and large farms (over thirty acres) are largely self-cultivated. Self-cultivation also predominates in farms with an area of 15 to 29.9 acres, except in Jullundur district.

(vi) In the medium sized farms (5.0-14.9 acres), tenant cultivation takes an edge over the owner-cultivation.

It may, however, be pointed out that the size of holdings has been decreasing and is bound to decrease further, owing to the present rate of increase in population and the scarcity of land available for cultivation (Table 7.12).

TABLE 7.12 CULTIVABLE AREA PER AGRICULTURAL WORKER IN BIST DOAB, 1960-61 TO 1967-68 (in acres)

Region	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68
Hoshiarpur	4.2	4.2	4.2	4.1	4.1	4.0	4.0	3.8
Jullundur	4.8	4.7	4.6	4.5	4.5	4.4	4.4	4.1
Kapurthala	6.5	6.4	5.5	5.4	5.7	5.6	5.6	5.2
Punjab	5.5	5.4	5.3	5.2	5.1	5.0	5.0	4.5

Source: Statistical Abstract of Punjab, 1969

LIVESTOCK: THEIR PLACE IN AGRICULTURE

The scarcity of data on livestock and its lack of detail does not allow comprehensive analysis. The present discussion will, however, portray the aggregate picture of the livestock structure and its pressure on cropland. For the sake of uniformity and comparability, it was necessary to convert the basic data (actual numbers) into animal feed units, which hereafter are referred to as 'livestock units'. As per the feed requirements of the animals, a weight was accorded according to the age and type of livestock. For this purpose, the conversion factors used are after Coppock (1971). For mapping the information, the common denominator used is cropped area (cropland). This will provide a measure of stocking intensity.

Two points may be made here before taking up the detailed discussion of livestock. First, the raising of livestock was not, until recently, an independent commercial enterprise. Rather, it has always been a secondary product of a largely subsistence agricultural economy. Secondly, the religious beliefs of the bulk of the Indian Community have always been a hindrance in the development of livestock enterprises. Whereas Moslims do not eat pork, Hindus consider eating beef a sin. Indeed, many Hindus do not eat any type of meat whatsoever. The situation remains largely unchanged even today.

In Punjab, however, where Sikhs form 55 per cent of the population, the situation regarding raising of livestock is different. Sikhs eat meat, though not beef. Sheep and goat meat is largely consumed, though poultry forms a fair percentage of the total meat consumption. The share of pork is insignificant and is reflected in its absence in the livestock.

Distribution and types

The function of livestock in Indian society has always been largely two-fold - to provide milk for human consumption and to provide draught for the various agricultural and non-agricultural operations. Hence, draught force and milch cattle jointly form a large part of the total livestock - 75 per cent in the Doab and 67 per cent in Punjab. If sheep and goats are added to these, the total percentage is 80, both in Punjab and the Doab (Table 7.13). Youngstock, mainly calves (both of cattle and buffalo) constitute the remaining one fifth. All other animals constitute less than one per cent of the total livestock.

TABLE 7.13 COMPOSITION OF LIVESTOCK, BIST DOAB, 1966

	Per cent of total livestock				
Region	Draught force	Milch stock	Sheep and goat	Young stock	Others
Hoshiarpur	33.8	44.1	2.3	19.7	0.1
Jullundur	33.0	39.9	10.3	16.7	0.1
Kapurthala	32.9	41.0	5.3	20.6	0.2
Bist Doab	33.3	41.6	6.5	18.5	0.1
Punjab	27.7	38.8	14.9	18.1	0.5

Source: Statistical Abstract of Punjab, 1969

Of all the categories of livestock, milch cattle takes the largest share, 42 per cent, followed by the draught force, 33 per cent, in The Doab. The corresponding figures for Punjab are 39 and 28 respectively. It may be noted here that sheep and goats share a much smaller proportion of the total livestock in the Doab, 6.5 per cent, as compared to the state average of 14.9 per cent. The reason for this low percentage is the wet and damp climatic conditions in most of the Doab, which are injurious to the health of these animals.

Draught force

In Bist Doab, draught force is essentially for agricultural operations, 70 per cent of which is contributed by bullocks alone (Table7.14). Buffaloes form another 26 per cent - largely male-buffaloes (she-buffaloes constitute only 4 per cent of the total buffalo draught force). The corresponding figures for Punjab are 74 and 13 respectively. The share of she-buffaloes is higher in Punjab, 12 per cent of the total buffalo draught force. It may be noted here that the she-buffalo has a larger share in the draught force in areas of subsistence agriculture as in Kapurthala and has a smaller share in areas of commercial farming such as Jullundur.

TABLE 7.14 COMPOSITION OF DRAUGHT FORCE, BIST DOAB, 1966

(Animal feed units)

	Oxen		Buffaloes		Others	
Region	Total units	Per cent of draught force	Total units	Per cent of draught force	Total units	Per cent of draught force
Hoshiarpur	73,500	70.4	26,925 (4.2)	25.8	4,050	3.8
Jullundur	95,325	72.9	29,850 (2.3)	22.8	5,550	4.3
Kapurthala	34,275	61.8	19,800 (7.6)	35.7	1,425	2.5
Bist Doab	203,100	69.9	76,575 (4.3)	26.3	11,025	3.8
Punjab	964,725	73.8	172,650 (12.1)	13.2	169,275	13.0

Figures in brackets indicate the percentage of she-buffaloes to total buffalo draught force.

Source: Statistical Abstract of Punjab, 1969

The spatial distribution of draught force in relation to total livestock is presented in Figure 7.8. From this, the following points can be made:

(i) Jullundur tahsil has the lowest percentage of draught force (under 16) owing to the higher rate of mechanisation of farming. Furthermore, due to industrialisation, the population density is high and consequently stock raising is limited.

(ii) In the subsistence farming areas of Kapurthala and Nawanshahr tahsils, draught force has a high percentage (over 32). In Phagwara tahsil, the percentage of draught force is high, due to intensive farming.

(iii) The percentage of draught force is moderate (16-32) in the whole of Hoshiarpur district and Nakodar and Phillaur tahsils of Jullundur district. In Hoshiarpur, the holdings are very small and most of its eastern hilly parts are rainfed and the percentage of area under cultivation is low.

It is clear, then, that the distribution and intensity of draught animals has its bearing on two factors - the level of farming and the pressure of population. In the region of commercial farming and denser population, the density of draught animals is low, but in areas of subsistence farming and sparser population, the density is high. With more mechanisation coming in, the density of draught force is bound to be lowered still further.

Milch cattle

Milch cattle account for 45 per cent of the total cattle in the Doab - slightly lower than the average of 48 per cent for Punjab. Of the milch cattle, the she-buffalo constitutes the largest, with 65 per cent. Cows form the remaining 35 per cent in the Doab as well as in Punjab (Table 7.15).

The spatial distribution of milch cattle is illustrated in Figure 7.9. It is interesting to note that Jullundur tahsil, which has a low

TABLE 7.15 TYPES OF MILCH CATTLE, BIST DOAB, 1966

(Animal feed units)

Region	Total cattle	Milch cattle		She-buffaloes		Cows	
		Total units	Per cent of total	Total units	Per cent of milch cattle	Total units	Per cent of milch cattle
Hoshiarpur	297,475	136,150	45.8	88,750	65.2	47,400	34.8
Jullundur	349,700	158,050	45.2	109,600	69.3	48,450	30.7
Kapurthala	158,170	69,200	43.8	38,850	56.1	30,350	43.9
Bist Doab	805,345	363,400	45.1	237,200	65.3	126,200	34.7
Punjab	3,826,700	1,828,700	47.8	1,173,800	64.2	654,900	35.8

Source: Statistical Abstract of Punjab, 1969

percentage of draught force as well as the lowest density of livestock per 100 acres of cropland, has the highest percentage of milch cattle (over 45). The reason for this is higher demand for milk due to bigger local market with a population of 0.22 millions. The percentage of milch stock is the lowest (under 35) in Garhshanker, Nakodar and Phillaur tahsils. Elsewhere, the share of milch cattle is moderate (35-45 per cent).

Milk production

Although milch cattle form the bulk of the livestock, yet they have not been able to provide sufficient milk to its large population. According to the present day dietary standards, the quantity of milk required for satisfactory maintenance of health should be at least 16 ounces per head per day (Indian Council of Medical Research, New Delhi). The availability of milk, judged by this norm, is quite low in the Doab as well as in Punjab (Table 7.16). The situation is satisfactory in Kapurthala district with per capita availability of milk per day of 17 ounces. Jullundur district lags behind with only 12 ounces of milk available per head per day. On the whole the situation calls for concern.

TABLE 7.16 PRODUCTION OF MILK IN BIST DOAB, 1969-70

(Kilograms)

Region	Annual production	Per capita availability Per annum	Per day
Hoshiarpur	152,952,000	151.3	0.415 (14.6 ozs.)
Jullundur	179,896,000	127.3	0.349 (12.3 ozs.)
Kapurthala	71,836,000	173.5	0.475 (16.8 ozs.)
Bist Doab	404,684,000	139.1	0.381 (13.4 ozs.)
Punjab	2,000,000,000	152.5	0.418 (14.7 ozs.)

Source: Economic and Statistical Organisation, Punjab

Recently, efforts have been made by the government to implement a number of schemes for the development of livestock in the state. In order to improve the milk yield as well as draught capacity of cattle and buffaloes, scientific methods for breeding, feeding, management and disease control have been adopted. With a view to providing an all-round development programme for animal husbandry, Intensive Cattle Development Projects are being established in the state. These efforts have improved the situation slightly in the last few years and are likely to increase the milk yield, but whether they can cope with the increasing population is yet to be seen.

Pressure of livestock on cropland

The overall pressure of livestock on cropland is high, 42 livestock units per 100 acres of cropland, in the Doab. The corresponding figure for the state is 37 (Table 7.17). The term pressure is used to convey an overall intensity of livestock per 100 acres of cropland. The aggregate intensity varies from 45 livestock units per 100 acres of cropland in Jullundur district to 39 livestock units in Hoshiarpur district - according to the demand of the people and carrying capacity of the land. Within the Doab, however, the variation is large, as is shown in Figures 7.10 to 7.13. From these figures, however, three spatial categories stand out.

(i) Areas of high density of livestock These include Hoshiarpur, Nawanshahr, Phagwara (40-50 units) and Phillaur (over 50 units) tahsils. In these areas of intensive irrigated farming (especially well irrigation) the demand for draught force is large. Moreover, these areas of intensive cultivation can support more heads of livestock. The density of livestock is the highest in Phillaur tahsil which has an additional advantage of a large market in the nearby (under 10 miles) neighbouring town of Ludhiana - one of the biggest industrial centres with a population of 0.25 millions. Phillaur tahsil supplies a substantial amount of milk, fodder and vegetables to this town. It may be noted here that Phillaur has high intensity of all major categories of livestock - milch stock (over 20 livestock units), draught force (over 15 livestock units) and sheep and goats (over 10 livestock units).

(2) Areas of moderate density of livestock The areas with moderate density (30-40 units) are largely the areas of subsistence farming such as Kapurthala, Dasuya, Garhshanker and Nakodar tahsils. Most of these areas have large uninhabited lands along the beds of the rivers Sutlej and Beas, called Bet, which are largely used for grazing the animals. For want of any incentive of a large or even local market, dairying has not gained any significance, though there is a scope for it. The milch cattle are kept largely for domestic use and the density of milch stock is relatively low

TABLE 7.17 PRESSURE OF LIVESTOCK ON CROPLAND, BIST DOAB, 1966

(Animal feed units)

Region	Total livestock		Milch stock		Draught force		Sheep and goats	
	Total units	Per 100 acres of cropland	Total units	Per 100 acres of cropland	Total units	Per 100 acres of cropland	Total units	Per 100 acres of cropland
Hoshiarpur	308,637	38.7	136,150	17.1	104,475	13.1	7,062	0.9
Jullundur	396,254	44.8	158,050	17.9	130,725	14.8	40,854	4.6
Kapurthala	168,712	42.7	69,200	17.5	55,500	14.0	9,042	2.3
Bist Doab	873,603	42.1	363,400	17.5	290,700	14.0	56,958	2.7
Punjab	4,710,364	36.9	1,828,700	14.3	1,306,650	10.2	703,164	5.5

Source: Statistical Abstract of Punjab, 1969

Cropland = cropped area

(under 15 units) in these areas (Fig. 7.11). In Garhshanker, Nakodar and Dasuya tahsils, the intensity of milch stock is the lowest in the region (under 15 units per 100 acres of cropland). The intensity of draught force is moderate (10-15 units). In Kapurthala tahsil the pressure is moderate in case of both Milch stock (15-20 units) and draught force (10-15 units).

(3) Areas of low density of livestock Jullundur tahsil has the lowest intensity of overall livestock in the region (under 30 livestock units). The density of draught force is the lowest (under 5 units) and in case of milch stock it is moderate (15-20 units). Though it has the biggest market (Jullundur) in the Doab, most of its needs are met from the adjoining areas.

In conclusion, it may be said that the need for more milk exists and will continue to exist for the near future, which calls for more milch stock and its improvement. On account of mechanisation of farming, the pressure of draught animals on land will decline. The demand for meat is increasing, though slowly. This would mean more sheep, goats and poultry, if not beef cattle or pigs.

Indeed, the development of livestock as a commercial enterprise and as a significant user of land has some critical social and economic implications. The competition between land for food and fodder is critical. With the increasing population, it is bound to be more critical still. Moreover, the proper use of livestock is not feasible unless people are willing to change their food habits and rise above the social and religious beliefs

SUMMARY

Bist Doab is the most densely populated region of Punjab. It has 2.4 million people in an area of 3,500 square miles and a density of 695. Over three fourths of its population is rural and varies from as high as 98 per cent in Garhshanker to as low as 50 per cent in Jullundur tahsil, depending upon the intensity and nature of farming as well as the level of industrialisation. Three factors contribute significantly to the distribution pattern of the rural population. They are: (i) the potential of agricultural land, (ii) availability of irrigation water, and (iii) the location of industry. A combination of these factors results in major concentrations of population around urban centres. Equally important, are the areas devoid of any settled population on the periphery of the Doab. On the whole, the region of diversified commercial farming exhibits high densities and the region of subsistence farming registers low densities.

Less than a third of the population was 'economically active' in 1961, of which female labour shared only 8 per cent, the rest being male. Two thirds of the 'economically active' population was engaged in agriculture, dominated by cultivators. Hired labour accounts for under one tenth of the total labour force. The distribution of agricultural labour force tends to vary according to the level of agricultural industrialisation. The general trend seems to be that the intensity of agricultural workers increases and the hired labour decreases with the increase in distance from: (a) urban centres, and (b) rainfed hilly areas and flood-affected areas.

A three-tiered structure characterises present land tenure organisation: peasant proprietors, proprietor-cum-tenants and tenants. Peasant proprietorship predominates with 84 per cent of peasants being either

owner cultivators or owner-cum-tenants. The mode of land tenure is individual peasant farming. The land owners cultivate their own lands and the proportion of share cropping is small and rents are generally high. Bist Doab is an area of small and medium sized farms. Self-cultivation predominates over small and large farms while in the medium sized farms, tenant cultivation takes an edge over the owner cultivation.

The function of livestock in India has always been to provide milk for human consumption and to provide draught force. Milch cattle accounts for 42 per cent, draught force, 33 per cent, and sheep and goats, 6 per cent. The draught force is constituted largely of bullocks, 70 per cent. Buffaloes form another 26 per cent. The pressure of draught force is low in the region of commercial farming and denser population, but high in areas of sparser population and subsistence farming. The number of draught force is declining due to mechanisation of farming. Milch cattle accounts for 45 per cent of the total cattle - 65 per cent she-buffaloes and 35 per cent cows - and their distribution is highly influenced by the market for milk. Consequently, their concentration is high near the industrial towns. The availability of milk is below the present-day dietary standards and calls for improvement in milk yield and production. The overall pressure of livestock on cropland is high and varies according to the carrying capacity of the land. The development of livestock as a commercial enterprise and as a significant user of land has some critical social and economic implications.

The fast increasing population in a resource-scarce situation could be threatening to the system, socially, economically and politically. Improvements in agriculture are needed urgently to feed the growing population. Perhaps, more important is to control the growth of population in Punjab, as in the rest of India.

PART IV

THE EMERGING AGRICULTURAL ENVIRONMENT

The transformation of agriculture in India has been one of the most spectacular features of the post-Independence period. Despite the planned efforts of the government, this transformation has been uneven in space, time and speed. Punjab (Bist Doab included) has provided a unique example in improving her agricultural set-up in the last two decades or so. This was made possible by a combination of factors which included human, physical, technical, social, economic and poiltical. The use of HYVs and self-controlled and assured water has played a great role in the process of agricultural development. Subsequently, farmers have been changing their techniques of farming as well as their land allocations to different crops. As a result of these developments, a dynamic and progressive agricultural environment has emerged.

The aim of this Part is to describe and analyse these emerging patterns and to provide a synthesis of these patterns. The first four chapters in this Part deal with the emerging patterns of: (i) overall land use, (ii) overall cropping, (iii) kharif cropping, and (iv) rabi cropping respectively. Chapter 12 provides a disaggregative picture of the spatial organisation of agriculture by way of micro-level studies relating to farm, village and market. The synthesis of emerging patterns, however, is presented in Chapter 13. The terms used are defined and listed in Appendix I.

CHAPTER 8

THE EMERGING LAND USE PATTERNS

The aim of this chapter is to capture the emerging patterns of land use in the Doab. Certain of the many land use elements in the total assemblage may be distinguished and each of these will be studied in turn. First, the aggregate picture of land use patterns is presented (Fig. 8.1). From the study and the analysis of Figure 8.1, the following points emerge:

(i) The area under forests is insignificant - constituting only one per cent of the total area of the Doab (Table 8.1). The only single tract with significant area under forests - 21 per cent of the total area - is Rakkar of Dasuya. This tract is the highest, hilly part of the Doab (over 2,000 feet above sea level). The steep hilly slopes favour forestry rather than any other economic activity. Elsewhere, the area under forests is negligible. The low percentage of area under forests does not reflect all the activity in planting and tending trees. Many trees are also planted along the sides of the roads, the railway lines, the canals and other drainage and irrigation channels. These are not included in the category of forests. Rather, they appear in the statistics as a part of non-agricultural land.

(ii) The share of non-agricultural land (forests not included) is almost double (24 per cent) that of Punjab (13 per cent). Again, the percentage of non-agricultural land is highest in Hoshiarpur, over 34 per cent, followed by Kapurthala (20 per cent), and is lowest in Jullundur district, about 14 per cent. The physical limitations on land use are appreciable

TABLE 8.1 LAND UTILISATION IN BIST DOAB, 1966-68 (in acres)

		Agricultural land		Non-agricultural land		Potential agricultural land
Region	Total geographical area	Net sown area	Current fallow	Forests	Land not available for cultivation	Land available for cultivation
Hoshiarpur	978,552	573,293	28,830	10,707	334,420	31,383
	(100.0)	(58.6)	(2.9)	(1.1)	(34.2)	(3.2)
Jullundur	859,939	672,952	55,179	7,413	124,377	1,236
	(100.0)	(78.3)	(6.4)	(0.8)	(14.4)	(0.1)
Kapurthala	167,000	320,426	6,672	3,294	81,546	1,236
	(100.0)	(77.6)	(1.6)	(0.8)	(19.7)	(0.3)
Bist Doab	2,251,162	1,566,671	90,677	21,414	540,343	33,854
	(100.0)	(69.6)	(4.0)	(1.0)	(24.0)	(1.5)
Punjab	12,425,000	9,722,333	513,000	223,333	1,575,000	387,000
	(100.0)	(78.2)	(4.0)	(1.8)	(12.7)	(3.1)

Figures in brackets indicate percentages

Source: Statistical Abstract of Punjab, 1966-68

District Statistical Abstracts of Hoshiarpur, Jullundur and Kapurthala, 1966-68

(Figs. 2.2 and 2.4). In fact, less of the total land surface is really suitable for agriculture in Hoshiarpur district than in many parts of Punjab.

(iii) The area under cultivation is overwhelmingly large throughout the region with the exception of the 'marginal lands' in the Bet and hilly tracts. On average, 73.6 per cent of the area of the Doab is under plough, against 82.2 per cent in Punjab. Within the Doab, Jullundur exhibits the highest percentage of cultivation - 85 per cent - and Hoshiarpur the lowest - 62 per cent (Table 8.1). The lesser proportion of area under cultivation in Hoshiarpur and Kapurthala districts is largely due to the abandonment of agricultural lands on account of natural hazards such as flooding in Kapurthala, and choe erosion and sand spread, in Hoshiarpur districts. These damaged areas depress the overall percentage.

(iv) Due to high intensity of population, cultivation is under pressure and the area under current fallow is very small, 4 per cent of the cultivated area. In this, the Doab reflects Punjab as a whole.

(v) The percentage of cultivable waste (potential agricultural land) is likewise very small - almost half (1.5 per cent) that of Punjab (3.1 per cent). In fact, cultivable waste land is virtually confined to Hoshiarpur district - 3 per cent . In the remaining two districts, it is negligible.

Having presented the overall picture of land use, an attempt can be made to analyse spatially the various land use elements. These are discussed under three major categories in the following order:

1. Non-agricultural land (forests and land not available for cultivation)
2. Potential agricultural land (cultivable waste)
3. Agricultural land (net sown area and current fallow)

Non-agricultural land

The spatial distribution of non-agricultural land is presented in Figure 8.2. From it, four categories emerge (Table 8.2).

TABLE 8.2 NON-AGRICULTURAL LAND AS A PERCENTAGE OF TOTAL AREA, 1966-68

Category	Per cent of total area	Frequency of occurrence	Per cent of total occurrences
1. Very high proportion	Over 40	51	14.2
2. High proportion	20-40	36	10.0
3. Moderate proportion	10-20	94	26.1
4. Low proportion	Under 10	179	49.7

From the study of Figure 8.2 and Table 8.2, it is clear that 50 per cent of the occurrences - covering mainly densely populated, irrigated and relatively better developed parts of the Doab - exhibit low proportion of non-agricultural land. More so, most of this land is under roads, railway lines, canals, settlements and other public projects. The areas with a low proportion of non-agricultural land correspond to 'The Flat Plains' physiographic region.

In another 26 per cent of the cases, the proportion of non-agricultural land is moderate and its distribution is scattered over the region - largely associated with the unfavoured parts of the flat plains and favoured parts of the marshy plains and flood plains.

The remaining 24 per cent of the occurrences exhibit an unusually high proportion of non-agricultural land and chiefly correspond to the 'degraded lands' associated with the physiographic regions: The Hills (over 1,000 feet above sea level), The Marshy Plains and to a lesser extent, The Flood Plains (Fig. 2.3). Most of the land in these parts is under lakes, river beds and rocky outcrops.

Two points may be made concerning the very small forest acreage. First, considering the present and future needs for timber and the case for restoration of deforested areas leading to soil erosion, there is a strong argument for planting more trees. Second, the afforestation in the hills will help in checking the flow of rain-water, and ultimately improve the deteriorated agricultural land in the plains.

Potential agricultural land

The category of 'cultivable waste' (regarded as potential agricultural land by the author) is deceptive in content. As defined by the Revenue Authorities, it does not include lands abandoned due to choe and river evulsions, most of which are cultivable. These lands are included in the category of non-agricultural land. Secondly, tree crops and groves, which form a part of cropland, are included in the category of cultivable waste instead. Considering these two points, the category in itself is misleading and cannot be given much weight, although the fact remains that the land available for future expansion in cultivation is meagre. Moreover, the farming techniques have improved and so have the cropping patterns. Hence the lands which were considered barren and uncultivable, can partly be cultivated directly and partly by reclaiming. Indeed, the land classification concepts themselves are outdated and need to be reconsidered and revised, though it is to be recognised that this will make future comparisons in time difficult.

The spatial distribution of potential agricultural land is presented in Figure 8.3 and frequency of distribution is given in Table 8.3. From the analysis of Figure 8.3 and Table 8.3, it is evident that over most of the region (73 per cent of the occurrences) the proportion of cultivable waste is low. In another 11 per cent of the cases, it is moderate. Only 16 per cent of the total occurrences exhibit high to very high proportion of potential agricultural land - largely in Kandi, Rakkar and Bet of Dasuya, parts of Kandi and Rakkar of Hoshiarpur, parts of Kandi and Bet of Garhshanker, and parts of Bet of Kapurthala tahsil.

TABLE 8.3 POTENTIAL AGRICULTURAL LAND AS A PERCENTAGE OF TOTAL AREA, 1966-68

Category	Per cent of total area	Frequency of occurrence	Per cent of total occurrences
1. Very high to high proportion	Over 40 20-40	57	15.8
2. Moderate proportion	10-20	41	11.4
3. Low proportion (minimal)	Below 10	262	72.8

Agricultural land

The category of agricultural land comprises net sown area (net cropped area) and current fallow, and is termed as 'cultivated area' or 'cropland'. The spatial distribution of cultivated area is presented in Figure 8.4. The map reveals that in most of the region, the percentage of area under plough is high, over 80 per cent of the total area. The high proportion of cultivation is a common feature of land use in Punjab. This is partly due to favourable physical milieu - level land, easily workable light soils, availability of water for irrigation - and partly on account of high pressure of population on land and the demand for more food in the country (of which the Punjabi farmer is conscious) in an attempt to cope with the continued food shortage.

From the study of Figure 8.4, three broad categories emerge (Table 8.4).

1. Very high proportion of cultivation Out of the total occurrences, about three fifths fall in this category. It largely includes Jullundur district,

Phagwara tahsil, Dona tract of Kapurthala, Sirwal and parts of Rakkar of Garhshanker and Hoshiarpur and Maira, Sirwal and parts of Bet of Dasuya tahsil. Elsewhere, in some isolated patches - where ecological conditions are favourable, the share of cultivation in total land use assemblage is high. Within this broad spatial category, however, over half of the occurrences exhibit an excessively high proportion of cultivation, over 90 per cent. Indeed, it is the region of irrigated farming, comprising areas irrigated by the Bist Doab Canal in the south and Shah Nehr Canal in the north and well/tube-well irrigated central parts of the Doab.

2. High proportion of cultivation In this category fall only 15 per cent of the occurrences. Spatially, the category is confined to (i) Bet tract of the Doab, largely Bet of Kapurthala; and (ii) Sirwal, Rakkar and Maira of

TABLE 8.4 EXTENT OF CULTIVATION, 1966-68

Category	Per cent of total area	Frequency of occurrence	Per cent of total occurrences
1. Very high proportion.	Over 80	210	58.3
2. High proportion.	60 - 80	56	15.5
3. Moderate proportion.	40 - 60	28	7.8
4. Low proportion.	20 - 40 and virtually no cropping	66	18.4

Hoshiarpur district. These areas correspond largely with intensive well/tube-well irrigated parts of the Doab. The density of population is relatively high.

3. Moderate proportion of cultivation Only 8 per cent of the cases exhibit moderate proportion of cultivation. This constitutes the intermediary zone and is found in the form of outliers in conjunction with both the highest

and lowest categories of cultivation. Though scattered throughout the Doab, its major concentration is in the Rakkar, Kandi and Bet areas of the Doab.

4. Low proportion of cultivation About 18 per cent of the occurrences fall in this category and are spatially localised on the periphery of the Doab. These are degraded areas comprising largely flood-affected, sandy and choe-infested parts.

Intensity of cultivation

Having established the extent of cultivation, the next step is to assess the use of the cultivated area. The extent of effective and efficient use of the cultivated area depends largely on the capability and initiative of the farmers and their advisers, particularly with respect to innovations in irrigation, fertilizers, improved seeds and pesticides.

TABLE 8.5 OVERALL INTENSITY OF CULTIVATION, 1966-68

Region	Per cent of cultivated area	
	Net sown area	Current fallow
Hoshiarpur	95.90	4.10
Jullundur	95.30	4.71
Kapurthala	96.97	3.03
Bist Doab	95.99	4.16
Punjab	94.99	5.01

Source: Statistical Abstracts of Punjab, 1966. 1967, 1968 and 1969

The expansion of irrigation and the urge of the Punjabi farmer to innovate has brought an increase in the intensity of cultivation, that is, the ratio of net sown area to fallow land. Consequently, in the Doab, indeed in Punjab as a whole, about 96 per cent of the cultivated area is normally now sown, leaving only 4 per cent of the agricultural land as fallow (Table 8.5).

Table 8.5 reveals that the overall percentage values do not deviate significantly from one region to another in the Doab. Yet the spatial analysis of the net sown area and current fallow (Figs. 8.5 and 8.6) brings out clearly the areas of high intensity of cultivation, as well as the areas of marginal cultivation. From the study and comparison of Figures 8.5 and 8.6, three categories emerge (Table 8.6).

TABLE 8.6 INTENSITY OF CULTIVATION, 1966-68

	Per cent of cultivated area		Frequency of occurrence		Per cent of total occurrences	
Category	Net sown area	Current fallow	Net sown area	Current fallow	Net sown area	Current fallow
1. High intensity of cultivation. (High ratio of net sown area to fallow)	Over 80	Under 20	317	327	88.0	90.8
2. Moderate intensity of cultivation. (Moderate ratio of net sown area to fallow)	60 - 80	20 - 40	28	25	7.8	7.0
3. Marginal cultivation. (Minimal ratio of net sown area to fallow)	Virtually no cropping	Over 40	15	8	4.2	2.2

1. High intensity of cultivation About 90 per cent of the occurrences exhibit high intensity of cultivation - over 80 per cent of the total cultivated area is sown. Of the total occurrences in the case of net sown area, 77 per cent of them show the percentage of net sown area to cultivated area of over 90.

The remaining 23 per cent represent areas with 80-90 per cent of the cultivated area sown. Again, more than half the occurrences exhibit as high as over 95 per cent of the net sown area under cultivation. Consequent to the high percentage of net sown area, the percentage of fallow land is small (below 20). More than half of these occurrences depict the percentage of fallow land as small as under 5. The remaining half is shared almost equally by areas with the percentage of fallow ranging between 5 to 10 and 10 to 20, respectively.

The areas with high intensity of cultivation largely correspond to irrigated, densely populated, commercial and diversified commercial regions of the Doab. They cover practically the whole of the Doab, except rainfed, dry, <u>choe</u>-infested parts and Bet areas.

<u>2. Moderate intensity of cultivation</u> The intensity of cultivation is moderate in about 8 per cent of the cases. The percentage of net sown area and current fallow to cultivated area ranges between 60-80 and 20-40, respectively. These occur in isolated patches - largely in the Bet areas of Kapurthala, Bet of Nakodar, Bet of Garhshanker, Kandi of Dasuya and Kandi and Rakkar of Hoshiarpur. These areas are associated with relatively favoured parts of the flood-affected and waterlogged region and ecologically unfavourable parts elsewhere. These areas can be more intensively cultivated by providing irrigation facilities in the drier parts and by improving drainage in the waterlogged parts.

<u>3. Marginal cultivation</u> Marginal cultivation is associated with the region of recurrent crisis. It is attributable partly to frequent flooding and waterlogging in the western margins and partly dry, sandy and rocky parts of the eastern margins of the Doab. These 'down graded lands' are largely the result of lack of effort to restore the use of these lands by the government.

Individual peasant farmers cannot do much for it involves large financial implications by way of constructing dams to check the overflow of the rivers. The percentage of net sown area in these parts is very small, uner 20, while the fallow takes its largest share of over 40. These areas constitute only 4 per cent of the total occurrrences but pose a big challenge to the farmer, the planner and the government. The situation will further deteriorate, if proper remedial measures are not taken.

SUMMARY

In the land use rank order, agricultural land comprising three quarters of the geographical area of Bist Doab, comes first. The non-agricultural land ranks second, followed by potential agricultural land. Forests are insignificant in the total land use domain. Over 95 per cent of the cultivated area is normally sown every year, giving a high intensity of cultivation. Fallow lands account for less than 5 per cent of the cultivated acreage. On the whole, pressure of population on land is increasingly high.

The implications of the existing land use are: (i) since most of the cultivable land has already been cultivated, the scope for future expansion in cultivation is very limited. This is confined to degraded lands which need reclamation; and (ii) consequently, the major breakthrough for the future lies in an agricultural development strategy directed towards enhancing the 'production-mix' by increasing the intensity of cropping.

CHAPTER 9

THE EMERGING CROPPING PATTERNS: OVERALL CROPPING

Having established the extent and intensity of cultivation in the preceding chapter, the next step is to assess how intensively the net sown area is being cropped. This largely depends upon the socio-economic influents which determine the feasibility of the enterprise the farmer chooses and the input intensity with which he farms. With assured supply of water and the availability of modern inputs - especially high-yielding varieties of seeds and commercial fertilizers - it became possible for the farmer to replace less profitable crops with more profitable ones and also to enhance the intensity of the use of the available land by growing two or even three crops in a field in a year. The implications of population growth over available land resource are in no way less important in conditioning the cropping patterns.

In this chapter, the focus is on the emerging patterns of intensity of cropping; on the utilization of cropped area in crop seasons; on failure of cropping; and on the overall pattern of cropping in the Doab. The discussion of the individual crops of both _kharif_ and _rabi_ crop seasons is presented in Chapters 10 and 11.

Intensity of cropping

The term 'intensity' has been used with a variety of meanings. Often, it relates to the ratio of inputs to land area. In the present context, however, it implies frequency of re-use of land, that is the percentage of cropped area to net sown area. For example, if one crop is grown in a field in a year, the cropping intensity is 100 per cent; if two crops, the intensity would be taken as 200 per cent. Occasionally, there is a third crop on the same field in a year, which gives intensity of 300 per cent - a special feature of truck farming areas around the urban markets, where quick maturing varieties of vegetables and fodders are grown.

The average intensity of cropping in the Doab is about 135 per cent (1966-68) and accords with the average for the state as a whole. The intensity is higher in the rabi crop season, over 73 per cent, against over 61 per cent in the kharif crop season. In most of the Doab, the total cropped area exceeds net sown area because there is always a part of the kharif crop area which is resown during the rabi crop season, significantly in the irrigated areas to utilise the left-over soil moisture of the kharif crops. The intensity of cropping varies from below 100 per cent to over 200 per cent depending on the degree of variability of physical, social and economic determinants and the human ingenuity.

The most direct explanations of the spatial variations of cropping intensity lie in the intensity of irrigation and reliability of rainfall (cf. Figs. 16.4 and 3.6). The correlation coefficient values were computed and mapped on the basis of sample villages for each of the assessment circles. This brings out clearly the areas of high positive correlation as well as low correlation values (Fig. 9.2). The overall coefficient value for the whole of the Doab comes out to be 0.7932 which is highly significant (0.1 per cent level).

From Figure 9.1 showing the spatial distribution of overall intensity of cropping, two major categories evolve (Table 9.1).

TABLE 9.1 OVERALL INTENSITY OF CROPPING, 1966-68

Category	Cropped area as per cent of net sown area	Frequency of occurrence	Per cent of total occurrences
1. Categories of expansion:			
i. Very high intensity	Over 200	91	25.3
ii. High intensity	150 - 200	160	44.4
2. Categories of stagnation:			
i. Moderate intensity	100 - 150	79	22.0
ii. Low intensity (crisis areas)	Below 100	30	8.3

1. Categories of expansion (Very high and high intensity of cropping)

The combination of high pressure of population, small size of holdings, availability of water for irrigation - largely self-controlled well and tube-well irrigation - and favourable soils offer prospects for double and even triple cropping in most of the Doab - a general characteristic of irrigated farming in Punjab. The human element, rich in experience of irrigated farming coupled with zeal and enterprise, is in no way less credited in making use of the new opportunities and initiatives offered by the new technology and increasing demand for agricultural produce.

Together, the categories of very high and high intensity of cropping comprise about 70 per cent of the total occurrences, though the share of the latter is overwhelmingly large, over 44 per cent. They largely cover areas which are free of menaces such as , flooding, waterlogging, choe-erosion and the like and are mostly irrigated. The category of high intensity of cropping is widespread over the whole of the Doab, except the weaker areas. The category of very high intensity of cropping, on the other hand, covers over one fourth of the total cases, but is significant an expression of the new trends of intensive and specialised farming in the region. The expanding markets - a reflection of expansion of urbanisation due to increased industrialisation - coupled with new inputs, improved means of transportation and better farming techniques, have created islands of very high cropping intensity scattered throughout the Doab within the widespread category of high intensity of cropping. Mostly these islands are localised and specialised around urban centres.

2. Categories of stagnation (Moderate and low cropping intensity) These categories comprise only 30 per cent of the occurrences and represent the weaker agricultural areas of the Doab. Over 22 per cent of the occurrences exhibit moderate intensity of cropping and concentrate mainly in Bet areas alongside rivers Beas and Sutlej and alongside East and West Beins - excess of water - and Kandi tracts in the eastern margins - lack of water coupled with choe-erosion. These areas are under continuous deterioration and if proper measures are not taken in time, they will heavily tax the agricultural economy of the region.

The category of low intensity comprises only 8 per cent of the total occurrences and confines itself to the marginal agricultural areas where either the soils have been completely depleted or waterlogged. Their major concentration is in the south-west at the confluence of the Beas and Sutlej rivers. Elsewhere they are few and in tiny patches. Though their share in the whole region is small, they pose very serious implications. There is evidence that due to the deterioration of the farming in this region and lack of other avenues of development, the population is shifting to other prosperous areas. Indeed the areas are so badly damaged that their reclamation is problematical.

Utilisation of cropped area in crop seasons

Most of the area under cropping is divided among two crop seasons. The third crop, though important in its own way, is relatively insignificant in its areal context and hence cannot be taken up separately. However, certain comments are made in the text at the appropriate places. These two crop seasons, kharif and rabi, often overlap for the simple reason that the cropped area in one season is often cropped in the second and sometimes in the third as well. On the whole, the share of kharif cropping in the total cropping is relatively smaller, over 45 per cent, as against over 54 per cent of the rabi cropping. Yet, over most of the Doab, where supplementary irrigation facilities are available to cover, completely or partially, the risks of crop failure, both the crop seasons almost share equally.

The seasonal contrasts in cropping can be explained largely in terms of availability, reliability and corresponding needs of water and the perception of the farmer in terms of the same. First, the summer crops require more water as the rate of evapo-transpiration is high due to high temperatures. Combined with this is the erratic and unreliable nature of summer rainfall which involves greater risks in farming. Farmers, sometimes to avoid risks, prefer not to plant any crop in high risk fields and choose to conserve summer moisture for more assured and high value winter crops. The winter rains, on the other hand, are more reliable and useful coupled with lesser water demands and corresponding low rate of evapo-transpiration.

The spatial distribution of kharif and rabi cropping is presented in Figures 9.3 and 9.4 and from the analysis of these, four categories of cropping emerge (Table 9.2). From the study of these figures and Table 9.2, the following points can be made:

(i) Over most of the Doab, both crop seasons share almost equally ranging between 40-60 per cent of the total cropping. Over 70 per cent of the occurrences fall in this category in both cases.

(ii) Marginal and low cropping is confined to weaker areas and together share over 20 and 15 per cent of the total occurrences in the kharif and rabi crop seasons respectively.

(iii) High cropping is concentrated in ecologically most favoured parts, mostly around urban centres, and constitute about 10 and over 14 per cent of the cases in kharif and rabi crop seasons respectively.

(iv) The spatial distribution of kharif and rabi cropping follows almost similar patterns to the intensity of cropping.

TABLE 9.2 KHARIF AND RABI CROPPING IN THE TOTAL CROPPING, 1966-68

Category	Per cent of total cropping	Kharif cropping: Frequency of occurrence	Kharif cropping: Per cent of total occurrences	Rabi cropping: Frequency of occurrence	Rabi cropping: Per cent of total occurrences
1. Marginal cropping (including no cropping)	-	24	6.7	27	7.5
2. Low cropping	20 - 40	49	13.6	28	7.8
3. Moderate cropping	40 - 60	253	70.3	254	70.5
4. High cropping	60 - 80	34	9.4	51	14.2

Failure of cropping

The crop which either fails to germinate, or dry up or is destroyed due to lack or excess of moisture, rust diseases, or any other natural hazards, is taken as crop failure. Crop failure is a common phenomenon in India as in other tropical countries, on account of severe weather and unreliable rainfall coupled with lack of resources and technological competence to overcome these hazards. Though irrigation has helped considerably in improving the farming stability, the gains are limited in other ways.

The average rate of crop failure in the Doab is a little over 6 per cent of the total cropping. Yet the regional variation is large, ranging from under 5 per cent to up to 15 per cent. The spatial distribution of crop failure is presented in Figures 9.5 and 9.6 for the respective crop seasons and from their analysis three areal categories emerge (Table 9.3).

TABLE 9.3 FAILURE OF CROPPING, 1966-68

Category	Per cent failure in respective crop season	Kharif cropping		Rabi cropping	
		Frequency of occurrence	Per cent of total occurrences	Frequency of occurrence	Per cent of total occurrences
1. Average failure	Below 5	217	60.5	178	49.5
2. Excessive failure	5 - 10 and Over 10	43	11.9	33	9.2
3. No failure including no cropping	-	100	27.8	149	41.3

From the study of Figures 9.5 and 9.6 and Table 9.3, the following points emerge:

(i) The extent of crop failure is higher in kharif than rabi crop season, both in terms of space and intensity.

(ii) In kharif, about 28 per cent of the occurrences register 100 per cent of maturity of crops while in rabi the same applies to over 41 per cent of the occurrences.

(iii) The intensity of crop failure is high (ranging from over 5 per cent to up to 15 per cent) in kharif crop season with about 12 per cent of the occurrences falling in this category, while it is only in about 9 per cent of the occurrences in the case of the rabi crop season.

(iv) The average rate of failure (below 5 per cent) occurs in over 60 per cent of the occurrences in the case of kharif. whereas in respect of rabi it is only 50 per cent.

(v) The rate of maturity is high in irrigated areas where farming is relatively stable and low in rainfed areas and areas where flooding and choe menace is common.

(vi) The excessive crop failure is confined to marginal areas only.

Overall cropping pattern

Although the transition from a purely subsistence economy to a market economy has been taking place since Independence, it is foodgrains - food cereals and pulses - that dominate the total cropping in the region, as in the rest of Punjab. Foodgrains constitute about 70 per cent of the total harvested acreage of both crop seasons. Fodders share 15 per cent and cash crops 11 per cent of the total harvested acreage. The remaining 4 per cent is accounted for by all other minor crops.

However, the predominance of foodgrains, does not in any way tend to characterise the Doab's agriculture as purely subsistence. In the case of Bist Doab, or for that matter Punjab as a whole, the distinction between subsistence crops and cash crops cannot be over emphasized because a good proportion of the foodgrains produced is marketed by the farmers, as is evident from Table 9.4.

TABLE 9.4 COMPOSITION OF MARKET ARRIVALS IN BIST DOAB AND PUNJAB, 1966-67 (in quintals)

Region	Foodgrains		Non-foodgrains		Total	
	Amount	Per cent	Amount	Per cent	Amount	Per cent
Hoshiarpur	372,000	97	13,000	3	385,000	100
Jullundur	672,000	85	116,000	15	788,000	100
Kapurthala	627,000	80	155,000	20	782,000	100
Bist Doab	1,671,000	85	284,000	15	1,955,000	100
Punjab	11,274,000	76	3,543,000	24	14,817,000	100

Source: Marketing Officer, Punjab

Moreover, Punjab is a net exporter of foodgrains. In 1968-69, for example, Punjab contributed 1,800,000 tons of wheat towards the National Procurement Scheme. However, for the sake of convenience and to avoid any technical argument, oilseeds, sugarcane and cotton are included in the category of cash crops, while all foodcrops are discussed under the heading 'food cereals'.

First, an aggregate picture of the cropping assemblage is presented. This is followed by an analytical account of crop rank order and finally the crop pattern regions are delineated. The cropping assemblage for each of the assessment circles is exhibited in Figure 9.7 and the factual aggregative data for the Doab is given in Table 9.5. From the examination of Figure 9.7 and Table 9.5, the following features of cropping emerge:

(i) The predominance of foodgrains in the cropping assemblage is noticeable throughout the Doab. In the hilly eastern parts and Bet areas, the share of foodgrains is relatively higher than in the central parts. Especially is this so because the former areas lack urban development and are relatively unproductive in terms of cash crops.

(ii) Of the food crops, wheat, wheat/gram, maize and rice are the major crops and together account for 94 per cent of the total harvested acreage under foodgrains. Pulses are relatively insignificant.

(iii) In the overall crop structure, wheat is the most dominant crop. Next comes maize, followed by wheat/gram and rice respectively. Wheat, the leading rabi crop, is the major staple food of the region and is the most widely grown crop in the Doab, as in the rest of Punjab. The hilly parts are the exceptions, where because of lack of irrigation, mixed wheat/gram gains significance. In the kharif crop season, maize is the leading crop and is concentrated in the rainfed hilly parts. Rice, on the other hand, is largely raised in the low-lying Bet areas of the Doab.

TABLE 9.5 OVERALL CROPPING PATTERN, BIST DOAB, 1966-68

Crops	Total acreage	Per cent of harvested area
A. Food cereals:	1,357,306	69.0
Wheat	655,180	33.3
Wheat/gram	197,518	10.1
Gram (Chick-pea)	29,698	1.5
Rice (Paddy)	146,538	7.4
Maize	298,834	15.2
Others	29,538	1.5
B. Food pulses:	20,719	1.0
Total foodgrains (A + B):	1,378,025	70.0
C. Fodder crops:	288,919	14.7
D. Cash crops:	220,854	11.2
Oilseeds	103,267	5.2
Sugarcane	81,481	4.2
Cotton	36,106	1.8
E. Miscellaneous:	80,435	4.1

Source: Lal Kitabs, Revenue records, Government of Punjab

(iv) Fodder crops rank second in the total cropping. The regional dispersion in the intensity of fodder cultivation can be explained in terms of higher concentrations near the urban centres.

(v) The cash crops, oilseeds, sugarcane and cotton, are largely confined to kharif cropping. Among oilseeds, groundnuts is the leading crop and is largely grown in Dona tract of the Doab. In these areas, the presence of sand dunes, lack of irrigation water and ease of cultivation favour it comparatively. Recently the high prices of groundnuts in the wake of rising demand for vegetable oils have further commended the crop. Sugarcane, though widely grown for domestic needs, has a major concentration around the processing centres, where it is grown as a cash crop. Cotton is grown throughout the region, but on a small acreage overall.

(vi) Vegetables for commercial sale are largely raised around the major urban centres. Elsewhere, their share is insignificant and they are mainly grown for domestic uses.

SUMMARY

Consequent on many improvements in the agricultural production-mix during the period under review, the overall intensity of cropping has been enhanced to 135 per cent. The variation in the intensity of cropping is largely linked with the amount and reliability of both rainfall and irrigated water. Rabi crop season has a higher intensity of cropping than that of kharif. This may be explained in terms of availability, reliability and corresponding needs of water of crops grown, and the perception of the farmer in terms of the same. Crop failure remains a regular phenomena, though the intensity of crop failure has considerably declined in response to improvements in irrigation facilities. The rainfed areas in the east are still more vulnerable to crop failure.

Foodgrains dominate, accounting for 70 per cent of the harvested area. This is followed by fodder crops, 15 per cent, and cash crops, 11 per cent of the harvested acreage. Wheat leads with over 33 per cent, followed by maize with 15 per cent of the total harvested area. Wheat/gram (mixed) accounts for 10 per cent of the harvested acreage and ranks third.

Further improvements in the crop production-mix as well as in intensity of cropping are possible and are urgently needed to feed the fast growing population. Many developments are on their way. Yet, improvements in irrigation and drainage facilities would help a great deal in reducing the risk of crop failure and ultimately produce a more stable farming structure.

CHAPTER 10

THE EMERGING CROPPING PATTERNS (CONTINUED): KHARIF CROPPING

In the ensuing chapters, an analytical account of individual crops, with a commentary upon their distribution maps, is presented. The patterns of distribution, it is recognised, are based in part on principles of adaptation, and in part on historical, social and economic considerations. This is presented in two separate chapters, the first deals with kharif cropping and the second with rabi cropping. The crops in each crop season are grouped into three broad categories: foodgrains, cash crops and fodders. Vegetables, though not significant in their gross acreage, represent a new trend in cropping pattern and therefore, are treated separately. Among food cereals only major crops are considered and discussed in detail. Minor crops have been ignored as they form a very insignificant proportion in the total cropping assemblage.

Although the overall dominance of foodgrains in the cropping patterns of both crop seasons is evidently recognised, it is in the kharif crop season that foodgrains share a much smaller proportion than that in the rabi crop season (Table 10.1 and 11.1). In kharif cropping, foodgrains account for 53 per cent, cash crops 23 per cent, fodders 19 per cent and miscellaneous crops the remaining 5 per cent of the harvest. This gives a more diversified pattern of cropping in the kharif season. It is, however, the food crops which form the most significant and charateristic sector of farming in Bist Doab. Therefore, it would be meaningful to present a combined picture of foodgrains distribution, before taking up individual crops in their spatial context.

TABLE 10.1 KHARIF CROPPING PATTERN, BIST DOAB, 1966-68

Crops	Acreage	Per cent of harvested area
A. Food cereals:	465,779	51.6
Maize	298,834	33.1
Rice	146,538	16.2
Others	20,407	2.3
B. Food pulses:	10,432	1.1
Total foodgrains (A + B)	476,211	52.7
C. Cash crops:	208,251	23.0
Oilseeds	90,664	10.0
Sugarcane	81,481	9.0
Cotton	36,106	4.0
D. Fodder crops:	171,056	19.0
E. Miscellaneous:	47,973	5.3

Source: Lal Kitabs, Revenue records, Government of Punjab

Foodgrains (Food cereals and food pulses)

The spatial distribution of foodgrains is presented in Figure 10.1 and from the study of this figure, four categories emerge (Table 10.2).

1. Predominately foodgrains-growing area Over one third of the total cases exhibit predominance of foodgrains, accounting for over 60 per cent of the harvested acreage. Within the category, about one third of the occurrences show as high as 80 to 100 per cent of the *kharif* acreage under foodgrains, while in the remaining two thirds this percentage ranges between 60 and 80. Spatially, the category is confined largely to the subsistence farming areas of Kapurthala and

TABLE 10.2 SHARE OF FOODGRAINS IN KHARIF CROPPING, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences
1. Predominantly foodgrains-growing areas	60 - 80 and over	131	36.4
2. Moderately foodgrains-growing areas	40 - 60	136	37.7
3. Low foodgrains-growing areas	20 - 40	61	17.0
4. Nominal foodgrains-growing areas or areas of nominal cropping	Below 10	32	8.9

Hoshiarpur districts. The distribution pattern, however, tends to show a distinctively high concentration of foodgrains in the north covering most of Bet, Maira, Rakkar and Kandi of Dasuya, and northern fringes of Kapurthala tahsil. In most of the Bet tract of Kapurthala and parts of Dasuya, Garhshanker and Hoshiarpur tahsils, the concentration of foodgrains is relatively small (60 to 80 per cent).

The high concentration of foodgrains in these areas is largely attributable to the physical unsuitability of these areas for most of the other *kharif* crops, lack of urban development and small size of holdings. In the northern and western parts, high rainfall, damper climate, inadequate drainage and availability of irrigation facilities favour cultivation of rice. This can thrive better than any other crop under the existing conditions. While in eastern parts, lack of irrigation facilities and sandy soils restrict the choice of crops.

2. Moderate foodgrains-growing area About 38 per cent of the occurrences fall in this category and share between 40 and 60 per cent of the harvested acreage. This largely represents the diversified farming region of the Doab - most of Phillaur, Nawanshahr, Phagwara, Hoshiarpur, Sirwal and Dona

Charhda of Jullundur, Bet of Nakodar, parts of Garhshanker, Dasuya and Kapurthala tahsils.

The direct explanation of this category lies in the fact that in these areas the food crops have to compete with other more renumerative cash crops - oilseeds, cotton, sugarcane and vegetables - and fodder crops. The factors accelerating the growing of these crops include the particular suitability of the region, industrialisation and subsequent urban development (which tended to create a demand for these specialised crops) and, finally, the new market and price incentives. Further, these areas are well served with irrigation facilities, mostly self-controlled well/tube-well irrigation, and other infrastructure of agriculture which act as a good booster to the diversification of farming economy. Reference to Figures 10.9, 10.10, 10.12, 10.14 and 10.16 will amply justify the above statement, as well as bring out the areas of significant importance in respect of these specialised crops.

3. Low foodgrains-growing areas In 17 per cent of the cases the area under foodgrains is low, ranging between 20 and 40 per cent of the kharif acreage. The category includes Dona Charhda and Dona Lehnda of Jullundur, parts of Dona of Kapurthala, Phillaur, Manjki of Nakodar and parts of Kandi of Garhshanker tahsils. These areas are those where crops such as vegetables (around urban centres), oilseeds (in Dona parts of Kapurthala and Jullundur) and sugarcane (near processing centres) attain high significance and subsequently reduce the share of foodgrains considerably.

4. Nominal foodgrains-growing area In under 10 per cent of the occurrences, the area under foodgrains is nominal, below 10 per cent of the harvested area. It includes two extreme areas: those where the cropping, on the whole, is minimal due to physical limitations - south-west parts of Kapurthala at

the confluence of rivers Sutlej and Beas - and those where the share of groundnut and vegetables cultivation is overwhelmingly large due to both their suitability and demand.

Maize (Zea mays)

Next to wheat, maize is the most important food crop in the overall cropping of the region. It is the leading kharif crop, sharing one third of the kharif acreage. Largely, it is a cereal used as human food, though a small proportion of the total crop is used as green fodder, and is widely grown in the whole of Punjab. Bist Doab shares about one third of both acreage and production of the State. Among the Indian States, Punjab ranks third in area, second in production and first in yield per unit area.

The crop and its cultivation Maize is grown on a wide variety of soils, but well-drained, aerated, deep loam soils are preferable. It is a heavy feeding plant and thrives best on fertile soils, which are adequately supplied with plant nutrients, particularly nitrogen and phosphorus. The crop requires considerable moisture and warmth from the time of planting to the end of the flowering period. For germination, the ideal temperature is 21^{o}C. The most critical time in the growth cycle of maize is at the end of tasselling. This is the period of greatest vegetative growth, when good supplies of water are essential. Standing water, however, could be catastrophic. During the later period of the growing period, maize needs a considerable amount of warmth and sunshine.

The sowing of maize is spread out over much of the early summer months. The crop intended to be grown for fodder is sown in March and April, and is ready for cattle feeding in about two months time. When raised for grain, it is sown in July and August. The usual seed rate for grain crop is 6 to 8 kilograms and about 12 kilograms for fodder per acre. The general practice amongst cultivators is to select good cobs from the standing crop before harvest. These cobs are retained as such, and stripped by hand at the time of next sowing. Generally the maize crop is planted by either pora or kera methods for grain, and the chhatta method for fodder crops (see glossary). The farmers's recognition of different methods of sowing is clear from the local Punjabi proverb: "Pora badshaw, kera wazir te chhatta faquir", which means that pora is the king, kera is the minister and chhatta is the beggar. Interculture is very common with maize and is practiced in different forms. A fodder crop is generally sown with a mixture of beans of various types, while in the case of the grain crop, usually various vegetables or melons are grown. These are easily picked up from the standing, open-planted, crop.

Once the crop is mature, harvesting, like sowing, is leisurely and is done in October and November. The usual practice is to leave the plants lying in the fields for 3 to 4 days after harvesting, before they are tied into bundles and stacked for further drying in the fields, while other crops are being harvested. Then as time permits, the ears are husked, largely by family labour, or sometimes by labour borrowed on a reciprocal basis, from the neighbouring farmer. The cobs are allowed to dry in the sunshine for a couple of days (generally on roof tops or in open courtyards), before thrashing or storing. Dried cobs are also stored whole until needed, and are then shucked and ground in amall batches. Flour made of maize is preferred to wheat flour for breads eaten in winter. The stalks and leaves are a major source of fodder. They have a high sugar content and are easy to store for use in winter, when the wheat crop - the major source of dried fodder most used in the summer - is still growing. No part of the plant is wasted - even the roots are used for fuel.

Given the utility for both fodder and grain, the properties of the plant present a continuum of possible choices. On the one hand, by dense planting with interculture and minimised inputs of labour and fertilizers, a reliable high-yielding fodder can be produced. It also provides a 'bonus' of edible grain. On the other hand, by more open planting and more intensive inputs of labour, water and fertilizers, a valuable grain crop can be produced. Whether a farmer chooses one extreme or the other, or some compromise, depends on both his needs and his resources. The maize crop demands expensive inputs but this is off-set to a large extent by greater flexibility in the timing and management of harvesting features. This helps to sustain the large seasonal acreage devoted to the crops.

The varieties grown are largely indigenous, being hard and relatively drought resistant. Their grains dry without shrivelling, and are hard enough to pop when heated in hot sand ('popcorn' is a winter treat sold in towns and at fairs). The most common varieties are Jullundur Local and Sathi. Jullundur Local variety is widely grown in Jullundur and Hoshiarpur districts and matures in about 80 to 85 days. Sathi, as the name suggests, matures in about 60 days and is a catch crop of most of the Bet areas along the rivers Sutlej and Beas. The hybrids are of very recent origin and occupy a limited acreage. In 1966-67, the hybrids accounted for 4.1 per cent, and in 1969-70, they shared 9.7 per cent of the total maize acreage in the state. The figures represent the average for the Doab as well. Among hybrids, however, Ganga 101 and Ganga Safed-2 are gaining prominence for their suitability and higher yields.

The common rotations used in the region are:

1.	Maize - wheat/barley/potatoes/berseem	(one year)
2.	Maize - potatoes - tobacco/potatoes	(two years)
3.	Maize - potatoes - sugarcane	(three years)
4.	Maize - linseeds - paddy - wheat	(Three years)

Spatial distribution and analysis The areal pattern of maize harvest is almost the reverse of that of rice. The areas of greatest maize intensity, where it occupies more than half of the harvested acreage, are confined to the eastern parts of the Doab, where it is grown as a rainfed crop (Figure 10.3). In the western parts, where it is chiefly grown as an irrigated crop, the intensity of its cultivation ranges from moderate to low, or even minimal in some cases. Reference to Figures 10.2 and 10.3 brings out clearly two belts, separated by 25 inches summer rainfall line, where the crop is grown under different ecological conditions and in varying intensity. However, the spatial distribution of maize (Fig. 10.2) suggests three major categories under which it can meaningfully be discussed (Table 10.3).

TABLE 10.3 INTENSITY OF MAIZE CULTIVATION, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences
1. Areas of high intensity	Over 40	124	34.5
2. Areas of moderate intensity	20 - 40	148	41.1
3. Areas of low intensity including no cropping	Under 20	88	24.4

1. Areas of high intensity of maize-cultivation Over one third of the total cases exhibit a high proportion of harvested acreage under maize, ranging from 40 to 80 per cent. Within the category, however, 25 per cent of the occurrences occupy 40 to 60 per cent of the harvested acreage. The category is largely confined to rainfed areas or partially well-irrigated areas of Hoshiarpur district. Elsewhere, it is in isolated pockets. The relatively important position of maize in these areas results mainly from the fact that this is the only suitable major food crop which can be grown under the

existing conditions. The lack of irrigation facilities does not favour rice, the other important cereal of the _kharif_ season or, for that matter, any other cash crop which demands higher inputs of fertilizers and water. Normal rains in the summer months, on the other hand, provide adequate insurance for the maize crop. Losses due to abnormal rains, however, are not exceptional. In 1957, for example, over 2,000 acres of the maize crop were damaged in Hoshiarpur district (Singh, 1960: 119).

2. Areas of moderate intensity of maize-cultivation The category of moderate intensity of maize-cultivation is widely distributed, comprising over 40 per cent of the total cases. The share of maize here ranges between 20 and 40 per cent of the harvested acreage. Largely, the category is confined to central Doab - mainly Jullundur and parts of Kapurthala and Phagwara tahsils. Here maize is grown both as a fodder and as a grain crop. Some of it is grown for commercial selling in the cities. Ecologically, these areas are most suitable for maize (in fact for most crops), but the competition from other cash crops is keen, thus reducing the importance of maize as a chief food crop of the _kharif_ season.

3. Areas of low intensity of maize-cultivation The category is largely confined to Bet areas of the Doab, with a major concentration in Kapurthala and Dasuya tahsils. Elsewhere, it is in isolated patches. The category includes areas of minimal cropping and areas where maize cultivation is low. In one third of the total cases in this category no cropping at all is found, mainly at the confluence of Sutlej and Beas rivers. In the remaining two thirds of the cases, the crop accounts for 10 to 20 per cent of the _kharif_ harvested acreage. The waterlogged conditions in these areas are very injurious to maize growing. Mostly these areas favour the rice crop, which can stand excess water during the rainy season.

Rice (Oryza sativa)

With 161,000 acres of area and 86,000 tons of production, rice is the second important crop of the kharif crop season in the Doab. On an average, it shares 16 per cent of the kharif harvested acreage, 85 per cent is irrigated. Bist Doab shares 19 per cent of both area and production of Punjab State. Despite the fact that Punjab is out of the principal rice-producing belt of India, most Punjab rice is exported to other states.

The crop and its cultivation Rice is a semi-aquatic plant and requires high temperatures and excessive moisture. For a good rice crop, water should preferably be kept standing throughout the growing period with occasional - preferably weekly - replacement of fresh supplies. It requires clays or clay loam to loam soils, with more or less impermeable sub-soils. For finer varieties, heavy soils are preferable, though coarse varieties can even be grown satisfactorily in light soils. The alkali (kallar) soils, which will not grow other crops to advantage, will give a good rice crop. Rice requires 15 to 20 irrigations to mature after transplanting.

The rice crop does not require much fallow cultivation, as is necessary for wheat or maize. Preparatory cultivation is mainly done in standing water, which is followed by sohage or dandal, to level and weed out the weeds. This process is locally known as kaddoo (see glossary). Just before planting, a couple of stirrings are given so that the rice field is thoroughly puddled and the mire is made as fine as possible, for maintaining good seedling vigour and weed control. This also helps minimise water losses due to deep percolation. Four to six ploughings and cross-ploughings are considered to be sufficient for bringing the land to a suitable condition for sowing the rice.

The general practice of sowing rice in the Doab, as in the rest of Punjab, is by transplanting seedlings grown in the nurseries. Broadcasting is hardly practised, though most of the immigrant farmers from Pakistan have practical knowledge of the method. In raising the nurseries, the dry method is largely practised. The seed is scattered at the rate of one seer (2 lbs.) per marla (30 square yards) on a sufficiently manured and well prepared piece of land. The seed is covered with a fine dressing of farmyard manure and water is gently applied. Later, water is given whenever necessary, taking care that the plot is neither too wet nor too dry. The seedlings are ready for transplanting after about 5-6 weeks time when they are 10-12 inches high. On an average, 2½-6 seers (5-12 lbs.) of seed sown in 2-4 marlas (60-120 square yards) give enough seedlings for one acre. The optimum time for sowing nurseries is from mid-April to mid-June.

The transplanting period begins from mid-June and continues practically until the end of July or even later. Seedlings are transplanted singly in the standing water at a distance of 9 inches from plant to plant. Usually hired labour is employed on a daily wage basis, or on a per acre contract basis, for the purpose. One or two weedings are normally enough to keep down the rank growth of weeds. The harvesting starts in late September and is usually finished by the end of November. This is done largely by manual labour, though mechanical harvesters have recently been introduced but are mainly used by wealthy farmers. The crop is cut with a sickle and then collected in a convenient place in the field. It is immediately beaten out by striking the sheaves against a small bund (embankment) erected for the purpose. After winnowing and cleaning, the marketable surplus is generally carted from the field to the local market. The amount required for domestic consumption and other related requirements is stored in the house, after drying it fully for one week or so in the open sunshine.

Rice is usually grown on the same land year after year. It seems that these lands are able to keep up their fertility, provided that the water supply is adequate. Occasionally rice is followed by a leguminous fodder crop such as *berseem* on a limited acreage. The use of urea and ammonium sulphate is generally practised, though in most cases the recommended dose of fertilizers is not applied, due to either, economic reasons or lack of supplies at the necessary time, or both (personal observation).

The varieties grown are *Jhona* 20, *Jhona* 277, *Jhona* 349, *Jhona* 351, *Palmal* 246 and *Basmati* 217. The improved high-yielding variety IR-8 is gaining prominence in the region. In 1968-69, over 8.5 per cent of the total rice of the Doab was under high-yielding varieties, as against 7.5 per cent in Punjab as a whole. In terms of average inputs, rice is highly demanding for human labour, high rents and land revenue, and moderate animal labour, seed and fertilizers.

Spatial distribution and analysis The climate and soils impose no serious restrictions for rice cropping over most of the region. Indeed, it is largely the irrigation water, which remains the decisive factor in fixing the limit for rice cropping, as the crop is mainly irrigation-based in the region, as in the rest of Punjab. The cultural and economic factors also tend to exert considerable spatial differentiation in rice cropping. The distribution pattern, however, reveals clearly that the most important rice-producing areas are those where the acreage under maize, the main food crop of the season, and other cash crops are very low or even minimal. An interesting *corollary* is presented by the eastern parts, which otherwise have adequate rainfall, but are for the most part devoid of rice cultivation. The central parts, however, exhibit a relatively low proportion of wheat acreage, despite the advantages of good soils and adequate irrigation facilities.

The following explanations may be offered to resolve these apparent anomalies. First, it is noticeable that rice tends to be more important among immigrant farmers and in areas where the cash crops meet particular difficulties. Consequent on the Partition of the country in 1947, a large influx of rice-growing farmers from West Punjab (now Pakistan) migrated and settled in the riverine belt of the river Beas, particularly in Kapurthala, Phagwara and Dasuya tahsils. These farmers not only brought technical 'know-how' and rich experience of irrigated-rice-farming with them, but also as a result of their long association with rice became accustomed to eating rice as a main dish. This was opposed to the dietary habits of the local people, who would only eat rice on special occasions. This factor diffused a new element in the existing cropping pattern, which with time gained significance. At the same time, expansion in irrigation during the post-Independence period and the vulnerability of these riverine areas to frequent flooding and subsequent waterlogging further enhanced rice cultivation. More so~~,~~ in that as a result of these physical limitations, the choice of crops was restricted.

The absence of rice in the eastern parts can certainly be explained in terms of restrictions imposed by the lack of water for supplementary irrigation, the porosity characteristics of the soils and the rugged terrain. The sub-soil water-table, for the most part, is low and small farmers find it uneconomical to tap it. The storing of rain-water for irrigation, on the other hand, faces a serious handicap on account of porous soils. It is maize which finds more favourable ecological conditions here, whilst in the central parts of the Doab, rice meets the established competition of other cash crops, such as sugarcane, oilseeds, cotton and vegetables.

Reference to Figure 10.5 and Table 10.4 clearly reveals that over 42 per cent of the total occurrences exhibit 80-100 per cent of the total rice

TABLE 10.4 INTENSITY OF IRRIGATION IN RICE CROPPING, 1966-68

Category	Irrigated rice as per cent of total rice area	Frequency of occurrence	Per cent of total occurrences
1. High intensity of irrigation	80 - 100 60 - 80 and over 80	175	48.6
2. Moderate intensity of irrigation	20 - 60	32	8.9
3. Low intensity of irrigation	Below 20	9	2.5
	no irrigation or no rice cropping	144	40.0

acreage as being under irrigation. To test the correlation between rice cropping and irrigation, Pearson's test was applied to the data. This was found to be highly significant at 0.1 per cent level for the region as a whole. Different correlation coefficient values for different regions are spatially presented in Figure 10.6, which clearly brings out areas of high, moderate and low correlational significance respectively.

In general, rice is grown largely in areas where:

(i) supplementary irrigation facilities are available

(ii) other crops meet particular difficulties

(iii) local human responses are favourable.

These factors, singly and/or in combination, tend to produce different intensity patterns of rice-cropping and these are easily recognisable in Figure 10.4. Over one third of the occurrences exhibit complete absence of rice cultivation. The remaining are grouped into three spatial categories (Table 10.5).

1. Areas of high intensity of rice-cropping Spatially, the category is mainly confined to the western parts of the Doab. About 15 per cent of the total occurrences exhibit high intensity of rice-cropping, 40-80 per cent. Half of

TABLE 10.5 INTENSITY OF RICE CULTIVATION, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences
1. Areas of high intensity	40 - 80	53	14.7
2. Areas of moderate intensity	20 - 40	46	12.8
3. Areas of low intensity	Below 20	133	37.0
Areas with no rice, including no cropping	-	128	35.5

these occurrences exhibit 40-60 per cent of the harvested acreage under rice, while the remaining half share between 60-80 per cent. The areas included are Bet and Maira of Dasuya tahsil - the old canal-irrigated area and the waterlogged areas - and some parts of Kapurthala, Phagwara and Nawanshahr tahsils, largely scattered alongside East and West Beins. The concentration of rice in these parts is associated with high intensity of irrigation and favourable human responses.

2. Areas of moderate intensity of rice-cropping Over 12 per cent of the occurrences exhibit moderate intensity (20-40) of rice cropping. These are the transitional areas between low and high intensity of cropping. These areas with favourable local conditions, have the advantage of growing other crops such as maize, sugarcane, fodder, etc., which reduces the acreage under rice.

3. Areas of low intensity of rice-cropping This category comprises 37 per cent of the cases. The rice crop accounts for less than 20 per cent of the harvested acreage. Within the category, over two thirds of the cases exhibit as low as under 10 per cent, while the remaining one third between 10-20 per cent of the harvested acreage. It includes most of the central parts of the Doab, most of the Jullundur district, Hoshiarpur tahsil and some parts of Dasuya, Garhshanker and Kapurthala tahsils. In these parts, cash crops compete strongly

and the human population are not very responsive to rice cultivation either.

Other food crops

The other food crops of the kharif season are mainly millets such as bajra (Pennisetum typhoideum), jowar (Andropogan sorghum), swank (Panicum colonum), mundwa (Eleusine coracana) and cheena (Panicum miliaceum). These minor crops gain some local significance, though for the most part, they remain unimportant in the total cropping assemblage of the Doab, as well as of Punjab generally. They are, in fact, 'gap-filling' crops and perform similar functions in the areas where they are grown. Jointly, they occupy about 2 per cent of the harvested acreage of the season. They are mainly consumed locally by the poorer classes of people.

They occupy relatively poorer soils and are mostly rainfed. Bajra can be grown on poor sandy soils while jowar requires a stiff loam. Swank, mundwa and cheena are light, poor cereals and are grown mainly on light soils. Amongst these, bajra is the most drought-resistant and hardy plant, while jowar occupies an intermediate position, being less drought-resistant than bajra but more so than the remaining crops. These are largely grown in areas where either the soils are unfavourable, or where other inputs, specially irrigated water and drainage facilities, are inefficient and inadequate to fulfil the requirements of the season's major food crops.

Mostly these crops are sown broadcast, beginning from early June to the end of July, and harvesting is done in September to early November. Relatively few ploughings and little care is required to produce these crops. The local varieties are widely grown. Within the group, bajra remains the most important and leading crop and, in recent years, hybrid bajra No. 1 has been introduced. This is highly responsive to improved cultural practices and high fertilizer applications. It can be grown both under rainfed and irrigated conditions, where it gives 60 to 100 per cent higher grain yield than the local variety. A yield of 10 quintals per acre, under rainfed, and over 13 quintals per acre, under irrigated conditions, can be realised. It matures in about 85 days.

These crops present a scattered and patchy distribution (Figure 10.7). Over 59 per cent of the occurrences exhibit complete absence of the minor crops, while in the remaining 41 per cent, they occupy a varying proportion of the harvested acreage. Three broad categories can be recognised (Table 10.6).

TABLE 10.6 SHARE OF MINOR FOOD CROPS IN KHARIF CROPPING, 1966-68

Category	Per cent of harvested area	Frequency of occurrence	Per cent of total occurrences
1. Significant share of minor food crops	Over 20	7	2.2
2. Moderate share of minor food crops	10 - 20	17	4.7
3. Low share of minor food crops	Under 10	123	34.0
Absence of minor food crops, including no cropping	-	213	59.1

The category of a significant share of minor food crops is limited to only just over 2 per cent of the total occurrences. This is largely concentrated in Kandi and Bit-Manswal of Garhshanker tahsil, in the east, and Dona of Kapurthala, in the west. These areas are, for the most part, rainfed, which restrict the choice of crops only to the dry crops. Under 5 per cent of the cases, record moderate intensity of these crops. This category is associated with drier and hilly parts of Hoshiarpur district and some parts of Kapurthala and Nakodar tahsils. About 34 per cent of the occurrences exhibit low acreage and are found scattered throughout the Doab, except those areas where assured water supply favours other more renumerative food and cash crops. On the whole, these are the decreasing crops. With the increasing improvement of ecology, they are likely to face a further recession.

Pulses

The main pulses of the kharif season are mung (Phaseolus mungo), mash (Phaseolus radiatus) and moth (Phaseolus aconitifolius). These are small beans, similar in size and shape to lentils, and are eaten in the form of a thick soup called dal, while the green provides a high protein element in fodder. In a largely vegetarian population, pulses take a very high place, and are the principal source of protein in the diet. They are indeed poor man's meat and are often used in conjunction with other foods rich in starch, for example, rice or wheat. Jointly, they occupy just over 1 per cent of the harvested acreage of the season.

Pulses are the least demanding of crops. With a meagre preparatory tillage, practically no weeding and less moisture, they act as insurance crops. A local Panjabi proverb explains it well: 'Jat ki jane rah, chhola ki jane wah, mahn ki jane ghah'. Translated into English it means that the farmer does not care for a regular path, gram can do well without any preparatory tillage and mash does not mind the weeds.

The soil and moisture requirements, however, vary slightly for each of the pulses. Within the group, moth needs light sandy soils with minimum moisture, while mash requires clay loam soils with maximum moisture. The requirements of mung, however, lie in between the two. They are sown broadcast from the beginning of June to the end of July, depending upon the monsoon, and harvesting continues from the end of September to the middle of November. The nitrogen-fixing ability of these and other legumes is well recognised in the pattern of rotation.

The spatial distribution of pulses is presented in Figure 10.8, and from its study these points emerge:

(i) About half of the total occurrences exhibit complete absence of pulses, while in the remaining half, they account for a modest acreage, below 10 per cent. The absence of pulses is attributed largely to three types of areas: the waterlogged areas around rivers and Beins, areas of specialised farming and finally choe-infested and sandy areas in the east.

(ii) In about 10 per cent of the cases, pulses attain between 5 and 10 per cent of the harvested acreage and are found scattered throughout with significant concentrations in Kandi and Maira of Dasuya and parts of Phillaur, Nawanshahr and Nakodar tahsils.

(iii) About 39 per cent of the total cases, scattered throughout the study area, exhibit very low acreage under pulses - under 5 per cent.

Oilseeds

Sesamum (*Sesamum indicum*) and groundnut (*Arachis hypogoea*) are the two main oilseed crops of the *kharif* season, the former sharing an insignificant proportion of the total area under oilseeds. In 1968-69, for example, sesamum recorded under 2 per cent of the acreage and under 1 per cent of the production of oilseeds, in the Doab. The groundnut remains the single most important oilseed of the Doab in the *kharif* season. Jointly, these oilseeds share 10 per cent of the *kharif* harvested acreage, which constitutes about 44 per cent of the total cash crops - slightly higher than sugarcane. On the whole, Bist Doab shares about 21 per cent of both area and production of oilseeds in the State.

The crops and their cultivation The soil and climatic conditions for the *kharif* oilseeds are very similar. The requirements for groundnut cultivation will be described here. Groundnut prefers a sandy soil - well-drained sandy loam and loam soils with well distributed rainfall for about 30 inches during the months of July, August and September are considered to be ideal. Two to three ploughings are enough. The sowing starts with the advent of the first good shower of monsoon rain and continues until the end of July. The groundnuts to be used for seed, are hand-shelled a day or two before sowing. The crop is sown by dropping the seed in the furrows made by the plough - a method called the kera method. Weeding and manuring are not common, though a couple of weedings are helpful in obtaining good yields.

The crop is ready for harvest in the middle of November. A reliable indication of maturity is taken to be the uniform yellowing of leaves as well as shedding of older leaves. The harvesting is easy, and is largely done by loosening the soil with a khurpa round about the top roots, where most of the pods are formed. The main root is cut by digging harder and deeper, and the plant and pods are pulled out. On an average, four persons can harvest an acre in one day. After harvesting, the plants are left in the field for almost a week to dry, and then collected in a heap at a convenient place for threshing. The pods are separated from the plants with a pitch-fork, and piled into a heap. The pods are then cleaned by winnowing. The bhusa obtained after winnowing, is considered a nourishing feed for cattle, because the groundnut is a leguminous crop. After winnowing, the produce may be dried for another week before it is stored or marketed.

Generally local varieties are grown, but the new varieties such as M 145, Punjab Groundnut No. 1 and C 501 are being accepted by the farmers who grow groundnuts on a commercial scale. The general rotation practised is groundnut - wheat/wheat-gram. The crop is useful in various ways. It provides Vitamin B to humans, excellent feed to livestock, especially in the form of groundnut cake, and adds humus to the soil, enriching the fertility.

Spatial distribution and analysis Spatially, oilseeds are largely concentrated in the Dona areas of the Doab. Here, they not only share a significant proportion of the harvested acreage of the season, but stand out as the first ranking crop in the total cropping assemblage. This concentration is correlated largely with loamy soils (Figure 4.2) and moderate rainfall. These soils are conducive to easy penetration of the crop's roots into the ground, and also provide excellent drainage. Moreover, lack of irrigation facilities and presence of sand dunes in these areas favour the cultivation of groundnuts more than any other crop. The persistent price increases of groundnuts during the post-Independence period, has given a great stimulus to the crop. Its consumption in the form of vegetable ghee and its use as an oil has increased manifold during this period. Its area increased from 93,000 acres in 1950-51, to 548,000 acres in 1968-69, and production increased from 25,000 tons to 203,000 tons for the same years, in Punjab.

In view of the competition from the high-yielding varieties of food crops, there is little scope for expanding acreage under oilseeds, and therefore, their production has to be increased through higher yields. This will call for replacement of existing varieties and extension of irrigation facilities. Adoption of moisture conservation and other dry farming practices in scarce rainfall areas is also essential to stabilize yields and production. Since the crop is largely rainfed, its acreage and production fluctuates considerably from year to year, depending on the nature and intensity of the monsoon.

The distribution of oilseeds is highly localised (Figure 10.9). From the study of this figure, it is evident that over most of the region, the crop is conspicuous by its absence. Over two thirds of the total occurrences register a complete absence of oilseeds. In the remaining one third, they range from under 5 per cent to up to 60 per cent of the harvested acreage of the season. However, three spatial categories may be recognised (Table 10.7).

TABLE 10.7 SHARE OF OILSEEDS IN KHARIF CROPPING, 1966-68

Category	Per cent of harvested area	Frequency of occurrence	Per cent of total occurrences
1. Category of high concentration	Over 20	34	9.5
2. Category of moderate concentration	10 - 20	22	6.1
3. Category of low concentration	Under 10	65	18.0
No oilseeds, including no cropping	-	239	66.4

The category of high concentration on oilseeds accounts for over 9 per cent of the harvested acreage and is localised in Dona areas of the Doab: Dona of Kapurthala, Dona of Nakodar and Dona Lehnda of Jullundur tahsils. These areas form the region of oilseeds supremacy, where oilseeds occupy from over 20 per cent to up to 60 per cent of the harvested acreage of the season. Within the category, about 5 per cent of the occurrences share between 40-60 per cent. While the remaining over 4 per cent registers between 20-40 per cent of the harvested acreage. Oilseeds are a major cash crop of the region and are grown on a commercial scale.

In over 6 per cent of the total cases, the share of oilseeds is moderate, ranging between 10-20 per cent of the harvested acreage. It includes Dona Charhda of Jullundur, Manjki of Nakodar and parts of Bet areas (mainly sesamum growing) of the Doab. In these areas, oilseeds have to compete with other food and cash crops, especially cotton, sugarcane, fodder and wheat. A part of the crop is consumed locally, while the major portion is sold in the market for cash.

The remaining 18 per cent of the occurrences exhibit low acreage, under 10 per cent. This category is spread largely over parts of Phillaur, Bet of

Nakodar, Retli and Bet of Nawanshahr and Kandi of Nawanshahr. Here, the crop is mainly grown for domestic needs.

Sugarcane (Saccharum officinarum)

Next to oilseeds, sugarcane is the second leading cash crop of the season. On an average, it shares 9 per cent of the kharif harvest. About 80 per cent of the crop is irrigated. In 87,000 acres, Bist Doab produced 100,000 tons of sugar (in terms of gur) which accounted for 22 per cent of the acreage and 20 per cent of production in Punjab (1968-69).

The crop and its cultivation Sugarcane is an unusual crop in several ways. It is a perennial, requires large inputs: labour, water, seed and fertilizers, and produces no appreciable amount of fodder. Harvesting is not done, necessarily, at the usual time or in a usual manner, and high transportation costs are involved. Finally, it is subject to government control.

The crop demands heavy loam soils with assured supplementary irrigation. Intensive preparatory tillage is essental for a good crop of sugarcane. It is sown in early March, before the beginning of the rabi harvest. The planting material consists of sets, the treatment of which varies greatly. The common practice, however, is to bury the whole cane in the ground, in late November or early December, until needed. The object of burying is to protect the rooting stock from frost, which could be very harmful to the buds. At the time of sowing, the sets are taken out from the buried cane. The sets consist of short sections of the stems or tops containing two nodes or joints and buds - usually a foot long. For a good stand, it is necessary to have 40,000 healthy sets per acre. Then these sets are placed, by hand, in furrows which are normally one foot apart. Thereafter the furrows are earthed-over.

The crop grows rapidly in the hot summer months until late November or early December. The crop is hoed and watered frequently. Harvesting generally takes place during the winter months, December to February, when the cane is cut and its stalks are processed or taken to market. The cutting and stripping is done by family labour, which may be supplemented by hired labour. Ratooning is a common practice, and often three consecutive crops are taken before sugarcane is pulled out of the field. It leaves the soil in a poor tilth so that preparation for the next crop is laborious.

However, the crop provides two essential elements of human diet, sugar and iron, neither of which is obtained in appreciable amounts by any other means. Raw sugar, gur, in various forms is eaten in large quantities. The green tops are used as fodder during the winter months, while the cane leaves are used as a fibre for making coarse ropes. The squeezed out stems are dried in the open and stacked for use as a fuel when boiling down the crop for making gur.

Till the late sixties, the local hardy varieties with low sugar content were commonly grown. In recent years, however, a number of new improved varieties have been introduced, giving considerably higher yields. The common varieties grown are Co. J58, Co. L.29, Co. 975, Co. 1158, Co. L.9, Co. J39 and Co. J.46.

Spatial distribution and analysis Sugarcane, like cereals, has a wide distribution (Figure 10.10). Only a few areas, on the periphery of the Doab, largely representing degraded lands, are devoid of sugarcane-cropping. Elsewhere, the crop shares a varying proportion of the harvested acreage. This shows the importance of the crop in the local ecology. Unlike cereals, it does not attain the status of a first ranking crop anywhere in the region. At the maximum, it appears as a third ranking crop in the cropping assemblage.

To some extent, sugarcane is cultivated on two different scales - for domestic uses and for cash sale to the sugar mills. To meet the local human and livestock requirements, it is grown on a limited acreage and is partially irrigated. Exception may be taken in those areas where the mean annual rainfall is below 25 inches and water requirements are high. The crop grown for cash sale shares a significant proportion of the harvested acreage and, for the most part, is wholly irrigated (Figure 10.11).

On the whole, sugarcane is associated with three factors: (i) loamy soils; (ii) processing centres and areas along the main road and rail routes; and (iii) the areas with over 25 inches of mean annual rainfall. These factors singly and/or in combination with each other, determine the intensity of sugarcane cropping, in the face of the established competition from other cereals and cash crops. However, three spatial categories may be recognised (Table 10.8).

TABLE 10.8 SHARE OF SUGARCANE IN KHARIF CROPPING, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of occurrences
1. Significant sugarcane-cropping	Over 20	28	7.8
2. Moderate sugarcane-cropping	10 - 20	128	35.5
3. Low sugarcane-cropping	Under 10	169	47.0
No sugarcane/ no cropping	-	35	9.7

1. Significant sugarcane-cropping Over 7 per cent of the total occurrences exhibit a significant share of sugarcane in the *kharif* cropping. Spatially, this category is concentrated around the sugarcane processing centres. The location advantage of these areas enhances the cultivation of sugarcane in many ways: due to minimum commuting distances (i) transport of cane to sugar mills is easy, efficient and inexpensive; (ii) surplus urban

labour is relatively easy to obtain when needed and (iii) use of urban composite manures and availability of other inputs. With these advantages, sugarcane competes favourably with other cereals and cash crops. The crop is wholly irrigated and is grown for sale to the mills.

2. Moderate sugarcane-cropping Thirty five per cent of the total occurrences register moderate intensity of sugarcane. The category lies mainly within the effective zones of the sugar mills (10 miles radius is recognised as the effective mill area) and areas along the main road/rail routes, where sugarcane collection points are set up by the administration to the advantage of the farmers. It includes Phillaur, Phagwara, Dhak, Retli and Daha Bet of Nawanshahr, Sirwal tract of Hoshiarpur district and Dona Charhda and Sirwal of Jullundur tahsil. In these areas, sugarcane is the main cash crop and hence most of the sugarcane is sold to the mills.

3. Low sugarcane-cropping This is the most widely distributed category, covering 47 per cent of the total occurrences. Within the category, about one third shows as low as under 5 per cent of the harvested acreage under sugarcane, and is largely confined to (i) areas above 1,000 feet, in the east; (ii) degraded lands in the Bet areas; and (iii) oilseeds dominated Dona tract. In the remaining two thirds of the cases, the share of sugarcane ranges between 5 to 10 per cent of the *kharif* harvest. This is scattered throughout Kapurthala and Nakodar tahsils, in the south-west, and Maira and Kandi tracts of Hoshiarpur district, in the north and east respectively. In the hilly parts, the rainfall is high and the crop is supplemented by partial irrigation. In the south-west, on the other hand, where mean annual rainfall is less than 25 inches, the crop is entirely irrigated. In these parts, the crop is chiefly raised to meet the domestic needs.

Cotton (Gossypium herbaceum)

Cotton is the principal light-fibre crop of the region. The other fibre crops include San-hemp (Crotalaria juncea) and Sankukra (Hibiscus cannabinus), which are grown on very small acreages for domestic needs and for purposes of green manuring. On average, cotton accounts for about 4 per cent of the harvested acreage of the Doab. It contributes about 3 per cent of the area and 2 per cent of the production of the State. These figures reveal Bist Doab as a modest cotton-producing area by any standards.

The crop and its cultivation Cotton can be grown on a variety of soils, but the most suitable is that which contains equal proportions of sand, silt and clay, together with a considerable amount of organic matter. Good drainage and aeration coupled with good moisture holding capacity are preferable for a good cotton crop. Heavy clays tend to delay maturity and result in excessive vegetative growth, which is undesirable from the standpoint of potential insect damage. During the period of vegetative growth, moderate rainfall (25-35 inches mean annual) is most conducive. A drier period should follow to allow the bolls to ripen and be picked. Occasional light showers during the picking season are desirable to prevent the premature opening of the bolls.

The crop is generally sown from mid-May to mid-June, after 5-6 preparatory ploughings. Often, it is sown broadcast. The thinning of the cotton crop is essential for obtaining a proper stand and is usually done when the crop is a month old. Pulses and vegetables are sown mixed with cotton to reduce soil evaporation and step up soil fertility. The importance of frequent weeding and hoeing is recognised by the farmers, as is evident from a Panjabi proverb: Jitni godi utni dodi - meaning that as you hoe so will the number of cotton bolls grow. As the crop needs frequent waterings, water supply remains the critical factor in its production. The picking of cotton starts from the beginning of September in the case of desi cotton, and beginning of November in the case of American cotton. The picking is done chiefly by women and children. Family labour is normally used, with the exception of those areas where the crop is grown on a commercial scale and where hired labour becomes necessary.

The crop is mainly irrigated with the exception of sub-mountain areas. In Punjab, over 96 per cent of the crop is irrigated. The aggregate figure for the Doab is 78 per cent. The local varieties are mainly grown in the Doab, as well as in Punjab. The long-staple American cotton is becoming popular slowly. In the Doab, desi varieties still predominate, 84 per cent. The corresponding figure for Punjab is 42 per cent.

Spatial distribution and analysis Cotton, like sugarcane, performs an important function in the local ecology and as such has a wide distribution. The only areas devoid of cotton are those where either waterlogging and flooding are frequent, as in the Bet areas, or where the soils are unfavourable, as in the coarse sands of Kandi and clays of Bit-Manswal. Elsewhere, cotton ranges between under 5 per cent to up to 20 per cent of the harvested acreage, in the Doab.

Two factors, availability of water for irrigation and the established competition of other cereals and cash crops, largely determine the intensity and distribution of the cotton crop. From Figure 10.13, it is evident that for the most part, the crop is wholly irrigated. The only exception is in the eastern region, chiefly areas with over 35 inches mean annual rainfall, where the crop is either unirrigated or partially irrigated. From Figure 10.12, two spatial categories emerge (Table 10.9).

The category of moderate acreage under cotton is confined to about 9 per cent of the occurrences and represents chiefly the areas where cotton attains a status of a cash crop. These areas form a continuous belt encircled by the cities of Jullundur, Nakodar and Nurmahal. Traditionally, these areas had been one of the important cotton-producing regions in the past. Presently the crop is experiencing a recession due to the encroachment of high-yielding varieties of cereals and other crops.

The category of low cropping of cotton comprises 71 per cent of the total cases, and is spread over the whole of the Doab. Largely, cotton cropping accounts for less than 5 per cent of kharif harvest. The crop, for the most part, is raised for domestic requirements. Very little, however, enters the market for cash sale. On the whole the crop is declining in importance.

TABLE 10.9 SHARE OF COTTON IN KHARIF CROPPING, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences
1. Moderate cotton cropping	Over 10	34	9.4
2. Low cotton cropping	Under 10	254	70.5
No cotton/ no cropping	-	72	20.0

Fodder crops

In the overall cropping pattern, fodder crops come next to foodgrains in Bist Doab, as well as Punjab, covering about 15 per cent of the harvested acreage. In the kharif cropping of the Doab, however, their share is higher, 19 per cent. Despite this impressive acreage under fodders, it is by no means adequate to feed the cattle of the region. Moreover, the State has very little natural grazing, and the public pastures are both very limited and in poor condition due to over-use, soil erosion and neglect. The availability of feed concentrates is equally inadequate.

The bulk of the ration consists of straw and roughage, supplemented with very little concentrates such as grain wastes and by-products of the grain milling industry - oilcakes and inferior grains. For the most part, the cattle are stall-fed. The only time when they are let free in the fields and allowed to graze on stubble, is after the harvest. Therefore, the cultivated crops remain the major source of dry and green fodder supply. The introduction of new hybrid varieties of cereals, which tend to be short, produce a lesser amount of straw and roughage. This may lead to a further fodder shortage.

The fodder crops refer to all grasses, legumes or other crops which are grown pure or in mixture to provide cut herbage for feeding green or for conservation in the form of hay or silage. The fodder crops in the summer array consist primarily in sorghum millets - <u>jowar</u>, <u>bajra</u> and maize. The other minor fodder crops include <u>guara</u>, cowpeas, <u>moth</u> and <u>mung</u>. All the fodder crops are grouped and treated together, as the data lacks details for individual crops. Practically all these crops are grown as food crops and the details of cultivation of each one of them have already been discussed. However, the raising and harvesting fodder plan, which will provide a variety of choice to the Punjab farmer, is adopted after Gill (1959) and reproduced in Table 10.10.

<u>Spatial distibution and analysis</u> Fodders, like cereals, are very important in the village ecology and are grown throughout the Doab in varying intensity. The complete absence of fodders is observed only in degraded lands where farming is practically abandoned. These constitute just over 5 per cent of the total occurrences. Again, fodder crops are grown on two different scales: on a small acreage to meet the requirements of the domestic livestock; and on a considerably larger acreage, for cash sale in the market, in order to meet the special needs of milch cattle and other related livestock, centralised in and around urban centres.

TABLE 10.10 RAISING AND HARVESTING FODDER PLAN UNDER PUNJAB CONDITIONS

Harvesting season	Fodder	Crop	Sowing season	Yield per acre (in maunds)
January	Japanese mustard, berseem (Egyptian clover), lucerne (alfalfa) ...	Japanese mustard	End of September to to October	300 to 600
February	Early oats, berseem, lucerne ...	Berseem	End of September	600 to 800 (five to six cuttings)
March	Oats, berseem, metha (fenugreek), senji, lucerne ...	Oats	October-November	300 to 400
April	Late oats, berseem, lucerne ...	Lucerne, metha	October-November	800 to 1,000 (eight to ten cuttings)
May	Berseem, Sudan grass, lucerne and grasses	Senji	October-November October	300 to 350 300 to 400
June	Sudan grass, maize, cowpeas, lucerne and grasses ...	Turnip, Sudan grass	September-October March-April	400 500 to 600 (three cuttings)
July	Sudan grass, jowar (sorghum), cowpeas, lucerne and grasses ...	Jowar	April to July	300 to 400
August	Sudan grass, jowar, cowpeas, lucerne and grasses ...	Makchari	July	400
September	Sudan grass, jowar, moth, Phaseolus sp., cowpeas, lucerne and grasses ...	Moth	April to July	200 to 300
October	Jowar, makchari (teosinte), guar, pigeon peas and lucerne ...	Guar Cowpeas	July April to July	300 200 to 300
November	Makchari, berseem, mustard, lucerne ...	Elephant grass	February	600 to 800 (four to five cuttings)
December	Berseem, lucerne, mustard, turnip ...	Guinea grass	February	300 to 400 (four to five cuttings)

Source: Gill, 1959

Three factors largely determine the spatial distribution and intensity of fodders; size of holdings in relation to pressure of livestock and humans; extent of available natural grazing facilities and public pastures; and access to urban markets. These factors, singly or jointly, produce a spatial pattern which tends to show the following associations:

(i) Areas around the urban centres show much higher intensity of fodder crops. So much so that the fodders enter as a first ranking crop in the overall cropping pattern of the Doab.

(ii) Areas of high pressure of livestock tend to be areas of high intensity of fodders (cf. Figs. 7.10 and 13.8).

(iii) Areas with relatively small holdings coupled with areas liable to frequent flooding and other like menaces, and which in turn provide grazing facilities, show lesser intensity of fodders.

Fodder crops of the summer array generally demand lesser irrigations than those of winter. As such, the crop, for the most part, is raised under rainfed conditions, largely in the eastern parts where summer rainfall exceeds 25 inches. In the areas around urban centres, where fodders are raised for cash sale, and areas in the south-west, where summer rainfall is less than 20 inches, the crop is largely irrigated, over 60 per cent (Fig. 10.15). Elsewhere the crop is partially irrigated.

The spatial distribution of fodders is presented in Figure 10.14 and from its study three broad categories emerge (Table 10.11).

1. Category of significant cropping Almost half of the total occurrences exhibit significant acreage under fodders. Within the category, however, over 5 per cent of the total cases exhibit as much as 40 to 60 per cent of the harvested acreage under fodders and is spatially localised around major urban centres. In over 43 per cent of the cases, the fodders account for 20 to 40 per

TABLE 10.11 SHARE OF FODDERS IN KHARIF CROPPING, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences
1. Significant fodder cropping	20 - 40 and Over 40	182	50.6
2. Moderate fodder cropping	10 - 20	110	30.5
3. Low fodder cropping	Under 10	49	13.6
No fodder/ no cropping	-	19	5.3

cent of the harvested acreage. This is largely distributed over Phillaur, Phagwara, Jullundur, Hoshiarpur and parts of Garhshanker tahsils.It also includes areas around minor urban centres such as Nakodar, Nawanshahr, Dhilwan, Dasuya, Tanda Urmur and Garhdiwala. The major portion of the crop is sold in the urban markets.

2. Category of moderate cropping About 30 per cent of the total occurrences register moderate acreage under fodder, 10 to 20 per cent. It includes mainly Dhak of Nawanshahr, Sirwal, central parts of Bet and Kandi (west) of Dasuya, eastern half of Nakodar, Dona Lehnda of Jullundur and central parts of Kapurthala tahsil. The crop is raised partially to maintain the domestic livestock, and partially for sale in the nearby markets.

3. Category of low fodder cropping About 14 per cent of the cases exhibit low proportion of the harvested acreage under fodder crops, under 10 per cent. It includes mainly parts of Bet areas of the Doab, Kandi (east) and Rakkar of Dasuya, and parts of Dona of Kapurthala and Nakodar. Access to the riverine belts and forests provide grazing facilities which help considerably in maintaining the domestic livestock. Whatever fodder crops are raised are consumed locally.

Miscellaneous crops

A number of minor crops serve special local needs. In Bist Doab, the miscellaneous crops include condiments, spices, garden crops and a variety of table vegetables. Together, they account for over 5 per cent of the kharif harvest. Among these minor crops, vegetables stand out to be relatively more important. Only vegetables will be discussed here. Other minor crops are simply ignored.

In the summer array, a large variety of vegetables are raised: tomato, baingon (Brinjal), bhindi/okra (Lady's finger), ghia kaddu (Bottle gourd), halwa kaddu (Red gourd / pumpkin), karela (Bitter gourd), ghia & kali tori (Sponge gourd), tinda (Squash melon), khira (Cucumber), petha (Ash gourd), tar (Long melon), kharbuza (Musk melon), tarbuz (Water melon), shakar-kandi (Sweet-potatoes) and arbi (Colocasia). They are grown on a variety of soils, but well-drained, aerated, deep loams are preferable. The sowing of most of the summer vegetables takes place from mid-February to mid-April, though some late varieties are sown as late as June-July. Preparatory tillage is very essential. The maturing time varies between 50 to 150 days depending upon the type of crop. On the whole, vegetables are capital-intensive crops and are very demanding: need heavy application of manures and fertilizers, regular waterings and weedings and above all, intensive labour.

Spatially, vegetables are highly concentrated around urban centres. A cursory look at Figure 10.16 will immediately reveal that over most of the Doab, practically no vegetables are grown. This accounts for about 84 per cent of the total occurrences. In the remaining 16 per cent of the occurrences, their share ranges between under 4 and up to about 16 per cent of the harvested acreage. The maximum concentration, however, is observed around two major urban centres, Jullundur and Hoshiarpur. Around minor urban centres, on the other hand, the intensity of vegetable acreage is small, under 4 per cent of the kharif acreage. The reasons for the distribution and intensity pattern will be discussed in chapter 13.

Although vegetables play a significant role in the human diet by providing a variety of minerals and vitamins, their use and cultivation is very limited. Traditionally, their consumption was practically confined to well-off sections of the urban population. During the last decade, however, the consumption and cultivation of vegetables have increased appreciably and is spreading to the villages as well. But, for the most part, the farmers in the rural areas seem to have lacked interest in growing vegetables, even for their own use. This may be due to two factors: first, the scarcity of capital and other inputs and secondly, perhaps more important, they do not perceive the usefulness of vegetables in their daily diet. With the spread of education, expansion in irrigation, improvement in means of transport and general awareness among the farmers, will definitely boost vegetable growing in the near future.

CHAPTER 11

THE EMERGING CROPPING PATTERNS (CONTINUED): RABI CROPPING

The *rabi* crop pattern (Table 11.1) is basically similar to the *kharif* pattern in its primary orientation towards local needs, and in the thoroughness with which its different components are utilised. The obvious departures are reflected in the overwhelming predominance of foodgrains - covering about 85 per cent of the *rabi* harvested acreage and, consequently, in a much lower acreage strength of cash crops - covering just over 1 per cent of the harvested acreage. The area under fodders and 'miscellaneous' crops is also smaller in comparison to the *kharif* crop season. The presentation of *rabi* cropping, however, follows a similar sequence to that of *kharif* cropping discussed in the preceding chapter.

Foodgrains (Food cereals and food pulses)

Foodgrains account for no less than 60 per cent of the *rabi* harvest throughout the Doab. Some areas virtually stand out as exclusively foodgrains-growing areas. Wheat - the staple food of the region, and for that matter of the whole of northern India - attains a very high status in *rabi* cropping, accounting for about 62 per cent of the harvested acreage of the season. When combined with wheat/gram (mixed), this contribution goes up to 80 per cent (over 43 per cent in the overall cropping). Wheat enjoys various advantages, both ecological and cultural, which makes it such an important and profitable venture in the region (infra).

TABLE 11.1 RABI CROPPING PATTERN, BIST DOAB, 1966-68

Crops	Acreage	Per cent of harvested area
A. Food cereals:	891,527	83.7
Wheat	655,180	61.5
Wheat/gram(mixed)	197,518	18.5
Gram (chick peas)	29,698	2.8
Others	9,131	0.9
B. Food pulses:	10,287	1.0
Total foodgrains (A + B)	901,814	84.7
C. Fodder crops:	117,863	11.1
D. Cash crops:		
Oilseeds	12,603	1.2
E. Miscellaneous:	32,462	3.0

Source: Lal kitabs, Revenue Records, Government of Punjab.

The distribution of foodgrains is presented in Figure 11.1 and from its examination, four categories emerge (Table 11.2). Spatially, these categories exhibit similar distribution pattern as were presented in *kharif* cropping, and the regional contrasts are largely attributed to factors explained elsewhere (Chapter 10). Moreover, these factors will emerge in the following discussion on individual crops of the *rabi* crop season.

TABLE 11.2 SHARE OF FOODGRAINS IN RABI CROPPING, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences
1. Exclusive foodgrains	Over 90	72	20.0
2. Very high proportion of foodgrains	80 - 90	141	39.2
3. High proportion of foodgrains	70 - 80	109	30.3
4. Moderate proportion of foodgrains	60 - 70	25	6.9
No foodgrains / no cropping	-	13	3.6

Wheat (*Triticum sativum*)

In 1968-69, Bist Doab produced about 700,000 tons of wheat from 862,000 acres, which accounted for 16 per cent of the acreage and 17 per cent of the production of the State. Amongst Indian States, however, Punjab ranks third in area, second in production and first in yield per unit area. This is the principal grain in the human diet, a major market crop and the main source of dry fodder for feeding livestock.

The crop and its cultivation Wheat is raised in a variety of soil and climatic conditions. It thrives well on all types of soils, except alkaline and waterlogged ones; but medium loams with good drainage and crumb structures are considered to be the best. Cool and moist weather at the time of sowing, light showers, when the plant is sprouting, and a well distributed rainfall, or alternative availability of supplementary irrigation, during its period of growth and finally high temperatures at ripening stage, offer the optimum conditions for wheat cultivation. Bist Doab, as well as Punjab as a whole, for the most part offers a well-balanced combination of these ecological conditions.

A deep and well-pulverised seed-bed containing ample moisture is very essential for raising a good wheat crop. The number of preparatory ploughings varies according to the crop that precedes it. Speed is important at the critical ploughing period, for the soil must be worked into a fine tilth before it gets too dry. Otherwise the wheat on unirrigated land may not germinate well and the wheat on irrigated land may have to be given a preliminary watering. Normally 5-6 ploughings, each followed by '<u>sohaga</u>' (a drag to smoothen the land) which helps in securing fine tilth and conserve moisture, are given.

The sowing operations commence from mid-October and continue till the end of November, though the optimum period is taken as first half of November. The '<u>pora</u>' method is commonly employed for sowing wheat, though seed drills are rapidly taking over. These seed drills are either drawn by a pair of bullocks or attached to the tractor. The seed rate varies in accordance with the variety, time of sowing and conditions of sowings. 25-35 kilograms (55-77 lbs.) per acre is commonly used. The seed is usually selected from the previous crop; and this was considered to be the best procedure before the introduction of dwarf varieties. Presently, with the predominance of HYV's, it has some obvious disadvantages, which the farmers do not perceive. The dwarf varieties are susceptible to rust diseases and need cyclic seed treatment. The farmers must perceive the significant necessity of changing their seeds every three years. One hoeing to keep down weeds is normally given about a month after sowing. In the irrigated wheat lands, this is generally followed by a watering. 4-5 waterings are adequate. The water demand, however, must be assured when higher doses of fertilizers are to be applied. Therefore, the dwarf wheat varieties to which liberal doses of fertilizers are usually applied, need two to three extra irrigations.

Harvest time is April. A hand sickle, the traditional appliance for harvesting is still largely used, though mechanical harvesters are now being introduced by the State. Hired labour on a daily wage basis/ on crop sharing arrangement basis, is employed. The plants, cut close to the roots, are tied into sheaves and left in the field for a couple of days, then carried to the village threshing floor. The threshing is done by making the bullocks tread on the crop, often yoked to a wooden frame-work called '<u>phala</u>', loaded with thorns and stones. The winnowing is done by lifting the wheat and chaff at arm's length above the head in baskets, and letting it fall gradually to the ground, so that the wind separates the chaff from the grain. However, this traditional way of threshing and winnowing is being replaced very fast by the country-made, power-driven mechanical threshers, which are reasonably cheap and easily available.

The grain needed for domestic use for the whole year is stored in village houses. The rest is usually marketed as soon as it is threshed, since debts must be paid and new purchases must be made, and the wheat must be delivered to the market centres before the rains begin in June or July, and village roads become impassable. Moreover, when the rains begin, ploughing for the summer crops must be rushed. There is no time then to take the grain to market.

Although the dwarf wheat varieties predominate, the local varieties such as <u>wadanak</u>, <u>mundri</u>, red wheat and vulgare wheat are still grown over a considerable acreage. The local population, for the large part, have not yet developed a taste for new wheats. These varieties are grown for domestic uses. It is interesting that these varieties obtain higher prices in the market. The improved varieties largely include kalayan sona, PV 18 and sonalika (S308). Others include C519, C518, C256, C306, C273 and C286.

<u>Spatial distribution and anlysis</u> Wheat as a major staple food crop has a wide distribution. Nowhere in the region, does it occupy less than 20 per cent of the <u>rabi</u> harvest, though the upper limit in some areas is as high as 80-100 per cent.

Considering the distribution pattern as a whole, the areas where high proportions of harvested acreage are under wheat are generally those which satisfy the plant's physical requirement best, and/or where there is no appreciable competition from other rabi crops. It is also noticeable, however, that the intensity of wheat cultivation tends to increase from east to west, though not necessarily in a way which can be explained in terms of physical conditions only. The established competition from other relatively more renumerative crops, such as vegetables and fodders, is evident and equally important in explaining these apparent differentials.

Irrigation emerges as the main factor which determines the distribution and intensity pattern of wheat cropping. The higher the rate of irrigation, the higher the intensity of wheat cropping and vice versa. This holds out specially when the major proportion of the wheat crop is taken by HYV wheats (Table 11.3), which demand more frequent and assured water supplies. The correlation coefficient analysis exhibits a highly significant correlation (significant at .1 per cent level for the region as a whole) between wheat cropping and intensity of irrigation. Furthermore, the distribution of correlation coefficient values brings out three spatial categories (Fig. 11.3) which coincide closely to the spatial distribution of wheat cropping (Table 11.4).

The association of loamy soils with wheat cropping is self-evident (cf. Figs. 4.2 and 11.2). These loamy soils present the ideal conditions for wheat cropping. They are moisture retentive and respond well to the fertilizers and irrigation water. The sandy soils of the eastern hilly parts, on the contrary, present a difficult environ for wheat cropping. The soils are highly porous and demand higher water requirements in the winter months (Fig. 3.15) when the crop is growing. The situation is further accentuated by lack of irrigation facilities.

TABLE 11.3 SHARE OF HIGH YIELDING VARIETIES AND IRRIGATED WHEAT TO TOTAL WHEAT, 1968-69

Region	Wheat acreage Total	Wheat acreage Irrigated	Wheat acreage Under HYV	Percentage of total wheat Under irrigation	Percentage of total wheat Under HYV
Kapurthala	150,736	126,520	91,430	83.93	60.66
Jullundur	410,201	354,107	296,531	86.33	72.30
Hoshiarpur	301,473	119,107	106,257	39.51	35.24
Bist Doab	862,410	599,734	494,218	69.54	57.31
Punjab	5,097,859	4,105,222	2,950,481	80.53	57.88

Source: Statistical Abstract of Punjab, 1969

From the examination of the distribution pattern (Fig. 11.2) of wheat and irrigated wheat (Fig. 11.4), three broad categories emerge (Table 11.4).

1. Predominately wheat-growing areas About two fifths of the occurrences exhibit predominately high proportions of the harvested acreage under wheat, over 60 per cent. Within the category, however, one fourth of the cases register as high as 80 per cent or more, while in the remaining three quarters, this percentage ranges between 60 and 80. Spatially the category is allocated to three different locations:

(i) Bet areas: where the crop, for the most part, is irrigated but not as intensively as in the central parts of the Doab. Rather, in some areas it is partially irrigated. This may be explained in terms of high moisture retentive capacity of most of the Bet loams and the corresponding low water requirements (Fig. 3.15) during winter months. Moreover, about half of the total wheat raised comprises local varieties, which demand relatively less water. The yields are low.

(ii) Manjki and Sirwal of Phagwara; Dhak and Retli of Nawanshahr; and parts of Dona tract of the Doab. The share of HYV wheats is overwhelmingly large and the yields are high.

TABLE 11.4 SHARE OF WHEAT IN RABI CROPPING, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences	Extent of irrigation	Correlation between wheat and irrigation
1. Predominately wheat-growing	Over 60	147	40.8	High to moderate	Highly significant
2. Moderately wheat-growing	40 - 60	112	31.1	High	Moderately significant
3. Low wheat-growing	20 - 40	79	22.0	Low/rainfed	Marginally/not significant
No wheat/no cropping	-	22	6.1	-	-

(iii) Kandi (east) and Rakkar of Dasuya; the wheat crop in these parts is entirely rainfed and composed of local wheats. The yields are very low.

On the whole, this category presents two contrasts: (a) the areas of high concentration of wheat grown under partial irrigation and rainfed conditions, marked by low yields and ultimately resulting in poor returns; and (b) the most promising wheat areas where under intensive irrigation, HYV wheats give high yields and subsequently returns are high.

2. Moderately wheat-growing areas Over 31 per cent of the occurrences register moderate proportion of wheat acreage, 40-60 per cent of the harvest. The category is largely localised in Jullundur district. Largely HYV wheats are raised under intensive irrigation. Although the proportion of wheat acreage in these parts is lower than that of the first category, nevertheless, these areas are much more important in terms of total production and the net returns to the farmers. Under assured water supplies, the region presents more stable wheat cropping base.

3. Low wheat-growing areas Under one fourth of the occurrences register low acreage under wheat. It largely includes Hoshiarpur and Garhshanker tahsils,

and some parts of Rakkar and Maira of Dasuya tahsil. The crop is partially irrigated and partially rainfed. Local varieties predominate and hence the yields are very low. Two major problems of the region, conservation of water and soil, depress wheat acreage considerably.

Wheat/gram (Mixed)

Next to wheat, mixed wheat/gram is the most important crop association of the season yielding over 18 per cent of the rabi harvest and comprising about 10 per cent in the overall cropping of the Doab. Sowing mixed wheat/gram has two advantages. Firstly, it minimises the risks of complete failure of cropping, as one of them, wheat or gram, might survive even under adverse weather conditions. For instance, if the rains are too meagre for the wheat crop to grow, gram being drought-resistant will survive. On the contrary, if the rains are heavy, wheat will survive, while the gram may not. Secondly, it helps in raising an additional crop from those fields which have either just produced a kharif crop and in which the soil moisture content does not offer ample time for sufficient ploughing for a pure-stand of wheat crop, or where irrigation water is not available for watering the fields before sowing the next crop. On the whole, these mixed stands are chiefly rainfed (Fig. 11.6) and often follow kharif fodders and cotton.

Management deferences for this mixed cropping are the order of priorities allocated to different food crops by the farmer in the assemblage of cropping. These priorities are based on the ecological relevance of the crops as perceived by the farmer. Wheat, for example, not only shares the largest acreage but also occupies the best land. Then comes wheat/gram, followed by gram and barley. Since sowing mixed crops was traditionally the usual way of diversifying agriculture in the past, it has still survived but mostly in areas with deficient and uncertain irrigation facilities and/or where cropping is largely rainfed.

Therefore, wheat/gram appears significantly in the rainfed eastern parts of the Doab, where under existing ecological conditions, mixed wheat/gram is probably the best choice in the rabi crop season. In the face of the meagre irrigation facilities, relatively higher winter rains (October to March) in these parts play a significant role in producing a good crop of wheat/gram in a normal farming year. In the remaining parts of the Doab, however, wheat/gram shares much less acreage and occupies those lands, which for one reason or the other, are marginal for wheat cropping. This pattern is evidently noticeable from Figure 11.5. An examination of the figure, however, suggests three spatial categories (Table 11.5).

TABLE 11.5 SHARE OF WHEAT/GRAM (MIXED) IN RABI CROPPING, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences	Extent of irrigation
1. High acreage	Over 45	57	15.8	Largely rainfed
2. Moderate acreage	30 - 45	62	17.2	Partially rainfed/ partially irrigated
3. Low acreage	Under 30	203	56.4	Largely irrigated
No wheat/gram/ no cropping	-	38	10.6	-

Together, the categories of high and moderate acreage of wheat/gram cropping account for one third of the cases and are allocated to two locations: (i) eastern hilly tract; and (ii) parts of Dona tract. In the former, the crop is raised under rainfed conditions, while in the latter case, the crop is largely irrigated. The category of low acreage has a wide distribution and is scattered throughout the Doab.

Other food crops

The other rabi food crops include gram (chick-pea) and barley (hordeum vulgare), the latter sharing an insignificant proportion of the harvested acreage in the Doab. Gram, though declining in importance, still appears strongly in some areas and shares a significant acreage of the rabi cropping. Therefore, the gram crop is taken up for further analysis while the barley crop is not.

Gram: chick peas (Cicer arietinum)

Gram accounts for about 3 per cent of the rabi harvest and over 1 per cent in the overall cropping of the Doab. In 1968-69, Bist Doab produced 12,000 tons of gram from 5,700 acres which accounted for 7 per cent of the acreage and 5 per cent of the production of the State. Considering acreage, the crop may appear very weak in comparison to other rabi cereals, but it is important as a cheap and valuable source of protein. Gram contains 20.5 grams of protein per 100 grams of dry weight as compared, for example, with 34.1/100 grams for soyabeans and 14.8/100 for beef (Watt and Merrill, 1963). It is consumed as a vegetable, when green, as a pulse, when dry, while its flour is eaten in various forms. It is also of considerable utility in raising the soil productivity, as it is nitrogen-fixing and is rotated with grains and fibres.

Gram thrives well on well-drained medium loams or light loam soils. However, it can be grown successfully in poor sandy soils which cannot sustain other crops. The crop is sensitive to alkaline soils. Normally rich soils are reserved for wheat, so gram is left with light soils. The crop does not require fine tilth but the soil should be well opened-up if it is not otherwise loose and well aerated. Deep tillage is, therefore, essential. The tilling is normally done during the months of July or August, when the crop follows fallow fields. This helps eradicate the weeds and loosen the soil, so that the subsequent rain is thoroughly absorbed. The optimum sowing period is the first fortnight of October, though it is sown even later. It is the earliest sown crop of the rabi season. It is generally sown broadcast. The usual seed rate is 20-30 kgs. per acre. The crop is rarely weeded. Sheep and goats are, sometimes, allowed to nip off the top shoots just before flowering, in the case of luxuriant growth, in order to encourage branching. Local varieties are largely grown though improved varieties have recently been introduced. It matures early and is normally harvested in March. The harvesting, threshing and winnowing operations are similar to those of the wheat crop. The crop is raised both under rainfed and irrigated conditions.

The crop is highly localised in its distribution (Fig. 11.7). Over 56 per cent of the total occurrences exhibit complete absence of gram, while in the remaining 44 per cent, the share of the crop varies from under 5 to 20 per cent of the harvest. Two broad categories may, however, be recognised (Table 11.6).

TABLE 11.6 SHARE OF GRAM IN RABI CROPPING, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences	Extent of irrigation
1. High proportion	Over 10	23	6.4	Rainfed
2. Low proportion	Under 10	136	37.8	Largely irrigated
No gram/no cropping	-	201	55.8	-

The high concentration of gram is notable in the south-eastern parts of the Doab, comprising largely of Bit-Manswal, Kandi (southern half), Rakkar and some parts of Bet of Garhshanker tahsil. The crop is grown entirely under rainfed conditions. The proportion of harvested acreage under gram is low, below 10 per cent, in Phillaur; Nawanshahr; Nakodar (except Bet); and Sirwal and Kandi (northern half) of Garhshanker tahsils. Elsewhere, the distribution of gram is limited, patchy and scattered. The crop for the most part is irrigated.

Food pulses

Lentils, as referred to in Chapter 10, are an important _dal_ crop, eaten throughout the year. With 24.7 gms. of protein, lentils are the most concentrated available protein source, slightly richer than _moong_. _Massars_ (_Lens esculenta_) are the single important pulse of the _rabi_ harvest, accounting for 1 per cent of the harvested acreage of the Doab.

The crop is raised under rainfed conditions, largely on light sandy soils. With very little preparatory cultivation; one or two ploughings, it is sown broadcast commencing from the end of October to the middle of November. The sowing of the crop as late as early January is not, however, unknown, though it results in very poor yields. The seed rate ranges between 12-15 kgs. per acre. All other operations connected with its production are similar to that of _kharif_ pulses. After keeping the required quantity for domestic uses, the rest is sold for cash in the local markets.

The spatial distribution of _rabi_ pulses is presented in Figure 11.8 and its study reveals very patchy distribution, and is largely encountered in Bet, Maira and Sirwal tracts of the Doab. Elsewhere, pulses are virtually absent.

Rabi oilseeds

Rabi oilseeds involve a group of crops: Indian rape (_Brassica napus Var, dichotoma_: _toria_), rochet (_Eruca sativa_: _taramira_), mustard (_Brassica juncea_: _rai_), Indian colza (_Brassica campestris Var. Glauca_: _sarson_), castor (_Ricinus communis: arind) and linseed (Linum usitatissimum: alsi). Together, they account for just over 1 per cent of the harvested acreage of the Doab. In the year 1968-69, Bist Doab produced over 2,000 tons of oilseeds from over 11,000 acres, accounting for just over 6 per cent of the acreage and over 5 per cent of the production of the State. It may, however, be mentioned here, that while recording, no precise distinction is made between various oilseeds, especially between rape and rochet and between mustard and Indian colza. They are principally recorded under linseed, rapeseed and mustard. In the present context, however, both for convenience and for more meaningful spatial analysis, all rabi oilseeds are grouped together.

Rabi oilseeds are raised on a variety of soils - mustard thrives best on light soils and linseed on heavy soils, while rapeseed is best on loams. A fine seedbed is required for good germination for most of the oilseeds. The sowing is done by both 'broadcast' and 'pora' methods, and usually commences in early September and continues to the end of October. Rapeseed, however, is the earliest, and linseed the latest, sown among rabi oilseeds. When they are sown mixed with other crops, the time of sowing is governed by the sowing of the main crop. The usual seed rate for rapeseeds and mustards is 2-3 kgs. per acre, while in the case of linseed, 8-10 kgs. per acre is normally used. They are raised both under rainfed and irrigated conditions. Two waterings, one at flowering and the other at pod formation, enhance the crop yield considerably.

The oilseed crops are generally harvested during March, a few weeks before the main harvest. The only exceptions, however, are rapeseeds, which are harvested during December and January, bringing the farmer a ready cash at the time when money is needed for paying revenue instalments in January. Mustard is the more important crop in its own way. It provides a principal dietary staple in the winter season. Women pick up the tender shoots and young leaves of the growing crop, each day or when needed, to cook them as a vegetable, called sag. This is relished especially with maize chapatis. Linseed is widely grown on the borders of the fields around the principal crops, for example wheat, to prevent damage to the main crop from passing animals, particularly goats. As shedding of seed occurs freely when the crop is ripe, the crop is removed to the threshing floor as soon as harvested.

All oilseeds are raised for domestic uses and for cash sale. The oil is used for cooking; as medicine; as a lubricant; and in the manufacture of soaps, varnish and paints. The oil cakes are used as livestock feed and the plant residues are used as dry fodder. As a legume crop, they add to the fertility of the fields.

The spatial distribution of rabi oilseeds is very scattered and patchy (Fig. 11.9). Over most of the Doab, the oilseeds are absent. In the remaining, their share ranges from under 3 up to 12 per cent of the harvested acreage, of the Doab. The maximum concentration of oilseeds is notable in three different locations - parts of Dasuya tahsil in the north, parts of Garhshanker tahsil in the east and Bet of Nakodar in the south-west.

Fodder crops

The fodder crops in winter array consist exclusively of legumes: Indian clover (Melilotus parviflora: senji), Egyptian clover (Trifolium alexandrinum: berseem), Fenugreek (Trigonella foenum-graceum: metha), Persian clover (Trifolium resupinatum: shaftal), Lucerne or alfalfa (Medicago sativa: lusan), turnips (Brassica rape: shalgam), and Japanese mustard (Brassica napus: japani sarson). Amongst these, berseem is the most important and widely grown fodder crop of the season. While lusan rarely appears in the cropping assemblage, the others are grown on a limited acreage. Unlike kharif forage crops, rabi fodders are largely perennial and semi-perennial, and provide high yields of very nutritious and palatable fodder in repeated cuttings throughout the winter season, from November to May. Jointly, they account for just over 11 per cent of the harvested acreage of the season.

The crop and its cultivation The rabi fodder crops, for the most part, demand almost similar water and soil requirements. They need frequent waterings at regular intervals and prefer heavily manured medium to heavy loams. The exceptions, however, are metha and lusan, which are relatively drought-resistant and can be raised under restricted conditions of available irrigation. They are invariably sown broadcast both in dry seed-beds and standing waters, the latter being the most popular. When sown dry, the fields are properly levelled and weeded before the seed is broadcast. This is followed by immediate light watering. The subsequent waterings are given at 15-20 days intervals depending upon the weather conditions. The seed rate differs from crop to crop: 8-10 kgs. for berseem and shaftal, 20-25 kgs. for senji and metha and 4-5 kgs. for lusan. Generally to attain higher yields of the first cutting, turnips, Japanese mustard and oats are sown mixed with major fodder crops. The crop is ready for first cutting in about 40-50 days time. The sowing and harvesting plan is presented in Table 10.10 (chapter 10) which may be studied with this account.

Whereas rabi fodder crops are very demanding and exacting, on the other hand, they perform two useful functions. Firstly, being legumes, they fix up the soil fertility. Secondly, they provide nutritive fodder and at the same time give high yields in repeated cuttings throughout the winter season. Thus they help to tide over the two periods of scarcity of green fodder during the year: December and then April to May.

Spatial distribution and analysis Unlike summer fodders, winter fodder crops are exclusively irrigated (Fig. 11.11). The factors which determine the spatial distribution and intensity of rabi fodders are the same as for kharif fodders (p.187). It may however be mentioned here, that the association between urban centres and intensity of rabi fodders has come out more strongly than in the case of kharif. This may be because the farmer normally has more time available to cart fodder crops to the cities during winter.

The spatial distribution of fodders is presented in Figure 11.10 and from its study three broad categories emerge (Table 11.7).

TABLE 11.7 SHARE OF FODDERS IN RABI CROPPING, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences	Extent of irrigation
1. High proportion	Over 20	62	18.9	Exclusively irrigated
2. Moderate proportion	10 - 20	153	42.5	Highly irrigated
3. Low proportion	Under 10	105	29.1	Largely irrigated
No fodders/ no cropping	-	34	9.5	-

1. Category of high proportion About 19 per cent of the total occurrences exhibit significant acreage, over 20 per cent of the harvest, under fodder crops. Spatially, the category is highly concentrated around almost all urban centres. The largest concentrations, however, are notable around Phagwara, Jullundur, Phillaur, Banga and Nurmahal. Away from the urban nucleations, Bet areas of the Doab, specially Bet of Dasuya, Kapurthala and Nakodar also register a high proportion of fodder crops at scattered locations. This may be due to the fact that during winter the livestock is exclusively stall-fed. The crop is largely grown for cash sale in the market.

2. Category of moderate proportion This category has a wide distribution and accounts for 10-20 per cent of the harvested acreage. Spatially, it comprises the whole of Jullundur district; Phagwara tahsil; most of the Kapurthala tahsil; most of Bet, Maira and Sirwal of Dasuya tahsil; and parts of Sirwal of Garhshanker and Hoshiarpur tahsil. The crop is raised largely for domestic livestock, though places close to the urban markets sell an appreciable proportion of fodder crops.

3. Category of low proportion The category is highly localised in rainfed parts of Hoshiarpur district, largely Rakkar, Kandi and Bit-Manswal tracts. It also includes parts of Bet, and Sirwal tracts. Outside Hoshiarpur, few areas, mainly degraded lands of Bet of Kapurthala and Nakodar register a low proportion of the harvested acreage under rabi fodders. Relatively fewer animals and restrictions imposed by soils coupled with lack of irrigation facilities could be cited as possible explanations for low acreage under fodders in these areas. Moreover, the fodders are raised entirely for maintaining the domestic livestock.

Miscellaneous crops

As referred to earlier, the 'miscellaneous' crops serve special local needs. The importance of various groups of crops in this category of 'miscellaneous' crops, however, is similar to that of the kharif crop season. Therefore, that is not repeated here. The rabi 'miscellaneous' crops account for 3 per cent of the rabi harvest. Amongst all, vegetables are significantly important for the reasons already listed in Chapter 10.

Like summer season, winter season vegetables, too, involve a large variety of crops: cole crops, cauliflower (Brassica oleracea: phul gobhi), cabbage (Brassica oleracea: band gobhi), and kohl rabi (Brassica oleracea:

gandh gobhi); root crops, carrots (Daucus carota: gajar), turnips (Brassica rape: shalgam) and radish (Raphanus sativus: muli); bulb crops, onion (Allium sativum: lassan); peas (Pisumsativum: matar); potato (Solanum tuberosum: alu); greens, spinach (Beta Bengalensis: palak) and fenugreek (Trigonella foenum-graceum: methi); and salad crops, lettuce (Lactuca sativa: salad) and celery (Apium greveolens: salahri). The most important from amongst these are potatoes, peas, cole crops and root crops. During the late sixties, potatoes gained a very high significance in the cropping assemblage. Two crops: autumn/and spring, are taken from the same field and is perhaps the most profitable crop raised in the region. In 1968-69, for example, Bist Doab produced 130,400 tons of potatoes from 25,500 acres, accounting for over 63 per cent of the acreage and production of Punjab State. Jullundur district records the highest yield, 13,377 lbs. per acre, in the State. Within the Doab, Jullundur leads both in acreage and production, followed by Hoshiarpur district.

The rabi season vegetables are raised on a variety of soils, but well-drained, heavily manured and aerated medium loams are preferred. They require cool and frost free weather during their growth. The sowing commences from early September and continues till the first half of November. Intensive tillage is a pre-requisite while regular watering is essential during the growing period of most of the vegetable crops. The maturing time varies between 100-150 days depending upon the type of crop. Salad crops, however, are ready for picking in about 60-80 days. Some early-maturing varieties of other vegetables may also mature in less than 100 days. On the whole, vegetables are capital, labour and transport-intensive crops. They are grown exclusively under irrigated conditions in the Doab, as well as in most of Punjab.

From the spatial distribution (Fig. 11.12) of vegetables, it is notable that over a considerable area, no vegetables are grown. These areas include mainly the rainfed areas in the east, waterlogged areas, mostly Bets of rivers Sutlej and Beas, and areas around both sides of the East Bein. Elsewhere, the area under vegetables ranges between under 5 and up to 40 per cent of the harvested acreage. Spatially, three categories may be recognised (Table 11.8).

TABLE 11.8 SHARE OF VEGETABLES IN RABI CROPPING, 1966-68

Category	Per cent of area harvested	Frequency of occurrence	Per cent of total occurrences
1. High acreage	Over 10	21	5.8
2. Moderate acreage	5 - 10	27	7.5
3. Low acreage	Under 5	162	45.0
No vegetables including no cropping	-	150	41.7

The high acreage under vegetables, over 10 per cent, is notable around urban centres - Jullundur, Hoshiarpur and Garhshanker. The category of moderate acreage under vegetables, 5-10 per cent of the harvest, closely encircles the areas of significant acreage under vegetables. It also appears around smaller urban areas comprising Phillaur, Nawanshahr, Tanda Urmur, Phagwara and Adampur. Both these categories represent areas of commercial vegetable growing. The category of low acreage under vegetables, under 5 per cent, is largely distributed throughout the Doab. Potato is the major crop for both domestic requirements as well as for selling in the market. This is the newly introduced crop in the cropping assemblage of the Doab.

CHAPTER 12

THE CASE STUDIES

In the preceding chapters (8-11), an aggregative picture of spatial and regional patterns of land use and cropping, which emerged during the period under review, are presented. The aim of this chapter is two-fold. Firstly, it will attempt to provide a disaggregative picture of the spatial organisation of agriculture by way of micro-level studies relating to farm, village and market. Hopefully, this will exemplify some of the findings and will 'act as an important supplement to and check upon the broad picture and general conclusions' (McMaster, 1962: 37), outlined in the preceding discussion. The second objective is to apply and demonstrate the application of Von Thunen's celebrated model of the location of agricultural production in the context of Indian environment.

This is presented in two sections. The first section will briefly describe the sites, general characteristics of agriculture, and provide a fairly accurate profile of land use patterns and cropping assemblage. The second section will deal with the zoning of crops and intensity of cropping within the village and around the market, based on a modification of Von Thunen's model.

For the purpose, two farms and five villages were chosen, as samples, from the different rural environments in the Doab. The selection emerged from a consideration of a combination of factors such as; the objective of the study, accessibility of the official documents, problem of scale, commuting time involved and the convenience in collecting the required information. The data were collected by the author personally and from the primary sources during the field studies, (p. 9).

SECTION 1: THE SITES, PATTERNS OF LAND USE AND CROPPING

A. The sites

The sample villages and farms are grouped into three sets, each representing the different locations and agricultural environments. The first set includes the farms, the second, three villages, and the third, two villages. Their locations and general features will follow the same sequence.

I. The first set of two farms chosen for this study are managed by S. Balram Singh and S. Surjit Singh. The former, an older and more experienced farmer, had only school education, while the latter attained a degree in agriculture. The farms are numbered 1 and 2 for the convenience of reference in the text. Both the farms are located in the village of Ucha Pind (Hadbast Number 112), tahsil Phagwara (Kapurthala), 10 kilometres south-east of Phagwara - a town with a large number of agricultural based and other small scale industries. It has a sugar mill as well. Ucha Pind is a large village with an area of 1.90 square miles and a population of 1,024. There are 151 occupied households in the village. It is connected to the main road leading to Phagwara by a metalled link road.

Farm 1 is a one solid block of 92 acres, owned by the family, with a farmhouse on the periphery, and is located at a distance of 1 kilometre on unmetalled road connecting the village settlement. Farm 2 is in three blocks, X, Y and Z, with a total area of 110 acres. Two of them (X and Y) are owned by the family, while the third (Z) is hired on lease from another absentee land-holder. The farmhouse is attached to block X and is situated on the periphery of the village settlement. The other two blocks are located away from the village.

Both the farms are partially mechanised and are largely operated by hired labour. Mechanisation is limited to the use of tractor, seed-cum-fertilizer drill, power-operated tube-wells and pumping sets. The use of the family labour is limited to the managerial work carried out by the two farmers, and one of their sons in each case. Self-controlled, open-channelled tube-well irrigation is largely employed. A section of the irrigation channel, however, was built underground in early 1968, by both farmers with the help of subsidy from the Agricultural Department of the State.

Both farmers are opposed to the idea of a 'land ceiling' on holdings (clearly it interferes with their interests) and favour 'mechanisation'. They tend to reject the thesis that mechanisation will lead to greater unemployment among the marginal farmers and landless labourers, arguing that while machinery may displace labour from some agricultural operations, on balance, farm mechanisation will probably increase employment by stimulating greater intensity of cropping and by enhancing the intensity of farm practices. They may also show greater dependence upon the urban centres for their implements, repairs, maintenance and other occupational and social requirments. It seems that in striving for better economic opportunities, they have shifted their occupational interests from the community. This attitude, however, has started affecting the community's solidarity and other aspects of social life. The economic values are gaining dominance over social values.

II. The second set of three villages was chosen from contrasting agricultural environments, so that singly they represent their own class but jointly illustrate the entire region under study.

1. Chak Alam (Hadbast Number 119) It lies 5 kilometres south-west of Dasuya (Hoshiarpur) on the Dasuya-Miani road, which passes through the fields of the village. The area of the village is 0.21 square miles and it is uninhabited - an absentee land unit (see glossary). Both owners and cultivators live in an adjoining village of Pandori - 1.5 kilometres in the south-west. The village has remained uninhabited since the time of the partition of the country in 1947, when Muslim residents left the village. The new allottees of the land chose to settle in Pandori, a larger centre, where more facilities for schooling, shopping, etc. were available. Most of them own a parcel of land in Pandori village as well. They have to traverse long distances to cultivate their fields in Chak Alam.

The village is mainly rainfed and inferior, extensive cultivation is practised. Due to the low level of the land, lying between Tarkiana and Nehran Jhil (Fig. 2.4), the land is submerged under water during the rainy season. This probably is the main reason that no improvement in terms of irrigation is taking place. There is only one well, which irrigates about 12 acres of land.

2. Alipur (Hadbast Number 294) The village lies 10 kilometres south of Jullundur city - the largest town of the region. In an area of 0.60 square miles it has a population of 273. The total households of the village are 66. The village is 1 kilometre from a metalled road. It is partially rainfed and partially irrigated by wells and tube-wells. The cultivation is more intensive in the irrigated fields, while the rainfed fields exhibit extensive cultivation.

3. Khambra (Hadbast Number 295) Khambra is a large village and lies 8 kilometres south of Jullundur city on the Jullundur-Nakodar road. The village is connected by a 0.5 kilometre long link road joining the main road. It has an area of 1.13 square miles with a population of 1,606 persons. The total number of households is 260. The village is wholly irrigated, mainly by wells and

tube-wells, and is largely intensively cultivated. The irrigation facilities provide ample opportunites for the choice of crops which is reflected in its crop pattern.

III. The third set of two villages lies in the effective sphere of an urban market and forms a part of the hinterland of Jullundur city. It is here that the influence of an urban market is highly reflected in the cropping patterns.

4. Noorpur (Hadbast Number 206) It is a village of moderate size, situated 5 kilometres north of Jullundur city, on the main Jullundur-Pathankot road. In an area of 0.64 square miles it has a population of 1,012 persons and 175 households.

5. Reru (Hadbast Number 207) The village lies 3.5 kilometres north of Jullundur city, on the Jullundur-Pathankot road. Its area is 0.72 square miles and has a population of 1,471 persons. There are 281 occupied households in the village.

Both villages described above are connected by metalled link roads to the main road. Both are wholly irrigated, exclusively by wells and tube-wells, which provide self-controlled irrigation with a high degree of reliability.

B. Patterns of land use and cropping

Crops are grown the year round. Most of them are worked into either a summer array (*kharif*) of fast growing hot weather crops, from July to September-October, or a winter array (*rabi*) suited to the longer, milder and drier season, from October to March-April. Sometimes, there is a third crop (*zaid rabi*, mid-summer) mainly vegetables and fodders, harvested in June. A few crops, the important among them is sugarcane - do not fit precisely into either category. In the present study, however, sugarcane is treated as a *kharif* crop, as is so recognised by the Revenue Department of the State. Orchards are exclusive of any category and are treated separately.

The amounts and distributions of crops reflect multiple considerations and among them the domestic needs - food for humans and fodder for livestock - remains the first and foremost. The farmer responds to water resources, energy supplies and land types by allocating his crops to those more durable portions of the overall system. Then he responds to the crops by deciding on the allocations of his own time and resources - labour, capital and price - to them in performing the operations they require. Ultimately 'the final decision involves a series of decisions at different levels of risk according to weather and the particular strategy the cultivator had been following prior to a particular decision' (Blaikie, 1971). (For more details, see, P.M. Blaikie, 1971; G.P. Chapman, 1973).

The data collected during the field studies are plotted and presented in Figures 12.1 to 12.6; for each of the crop seasons for the agricultural year 1968-69 in respect of the sample farms and villages. The year 1968-69 was considered as a normal agricultural year. The spatial analysis of land use and cropping patterns is now pursued for each of the two sets (two farms and three villages) separately.

<u>I. The farms</u> <u>Land use</u> The land use statistics derived from the basic data are presented in Table 12.1, and a cursory look at the table will bring out the following points:

(i) Over 95 per cent of the total area of the farms is under cultivation, leaving only under 5 per cent as non-agricultural - largely used for settlement, ponds, graves and tracks.

(ii) Of the cultivated area, over 98 per cent is normally sown, exhibiting a high pressure of cultivation.

(iii) Most of the area is sown more than once, giving cropping intensities of 208 and 163 per cent for Farm 1 and 2 respectively. The share of fallow is insignificant (under 2 per cent).

TABLE 12.1 FARM LAND USE PATTERN, 1968-69

(acres)

	Farm 1	Farm 2
Total area	92	110
Cultivated area (Cropland)	90	105
	(97.8)x	(95.4)x
Non-agricultural land	2	5
	(2.2)x	(4.8)x
Net sown area	89	103
	(98.8)xx	(98.1)xx
Current fallow	1	2
	(1.2)xx	(1.9)xx
Area sown more than once	96	65
	(107.9)xxx	(63.1)xxx
Total cropped area	185	168
	(208.0)xxx	(163.1)xxx

Note: Figures in brackets are percentages
x per cent of the total area
xx per cent of the cultivated area
xxx per cent of the net sown area

Source: Field work and Revenue records

Cropping Food crops dominate the cropping scene in both the farms (Figs. 12.1, 12.2 and Table 12.2). In Farm 1, about three fourths, and in Farm 2, four fifths of the cropped area is under food crops. Cash crops share significantly with 17.8 (orchards not included) and 6.5. per cent in Farms 1 and 2 respectively. Among the cash crops, sugarcane is the leading crop in both farms, though cotton and oilseeds (Toria) share significantly in Farm 1. Other crops include fodders and vegetables, which are grown exclusively for domestic requirements.

With the availability of self-controlled irrigation, new wheat seeds, assured price and favourable soils, wheat remains the leading crop on both the farms, sharing over one third of the cropped area in Farm 1 and over half of the cropped area in Farm 2. Maize is the second crop (12 per cent of the cropped area) in Farm 1, while in Farm 2, rice is the second crop (20 per cent of the cropped area). Due to the low-lying nature of the northern half (north of the drain, Fig. 12.1) of block Y, rice is more suitable as it can withstand temporary occassional flooding during the rainy season. In Farm 1, food pulses are also significant and come very close to sugarcane in the rank order.

Apart from the favourable ecological conditions for the cultivation of sugarcane, the location of a sugar mill at Phagwara further enhances its scope. Moreover, sugarcane remains the main source of cash income and employment in the off-peak season for a large number of peasant farmers. Although sugarcane is the major cash crop of the region, both the farmers are confident that cultivation of sugarcane was not especially a profitable venture. They find wheat and rice - two crops from the same field - are more profitable and less bothersome than sugarcane. Moreover, sugarcane demands more labour in different

TABLE 12.2 FARM CROPPING PATTERN, 1968-69

Crops	Acreage		Per cent of cropped area	
	Farm 1	Farm 2	Farm 1	Farm 2
Food cereals:	90	127	48.7	75.6
Wheat	64	94	34.6	56.0
Maize	22	-	11.9	-
Rice	-	33	-	19.6
Others	4	-	2.2	-
Food pulses and vegetables:	17	2	9.6	1.2
Cash crops:	33	11	17.8	6.5
Sugarcane	16	11	8.6	6.5
Cotton	10	-	5.4	-
Oilseeds (Toria)	7	-	3.8	-
Fodder crops:	8	7	4.3	4.2
Others:	-	1	-	0.6
Total:	148	148	80.0	88.0
Orchards:	22	-	12.0	-
Grand total:	170	148	92.0	88.0

Note: The total is not 100 per cent as sugarcane standing crop and some other minor crops are not counted

Source: Field work and Revenue records

operations, especially at the time of harvesting. However, they suggested that sugarcane can compete with wheat and rice, if the price paid by the mill is raised to Rs. 12.50 per quintal weight - an increase of 71 per cent over the existing price of sugarcane of Rs. 7.30 per quintal weight.

In Farm 1, orchards consisting of peaches, plums, oranges, jaffas, grapes, pears, guayas and pomegranates are grown in 22 acres, sharing 12 per cent of the cropped area. Though the farmer is proud of his knowledge of fruit farming, growing fruit trees was not his original intention. The probable reason was that these fruit trees were planted to escape from the Land Ceiling Act, for the Act provides exemption of land under orchards from ceiling. Most of the big farmers in the state did this, although the farmer would not admit that this was the reason. However, the credit goes to the farmer for putting the idea of fruit farming into practice and in attaining success.

In summary, the following points can be made from the preceding analysis:

(i) In Farm 1, a more diversified cropping with a significant acreage under more renumerative and labour and capital-intensive crops, such as sugarcane, cotton, orchards, oilseeds is practised. While in Farm 2, a simple cropping pattern, concentrating mainly on two crops, wheat and rice, is practised. This difference in cropping pattern may be attributed to the different perceptions of the two farmers.

(ii) Though the patterns of land use are similar, the interesting contrast being in cropping patterns in both farms, there is a greater variety and a more marked tendency to interplant crops in Farm 1, than in Farm 2.

(iii) The spatial distribution suggests that transport, capital and labour-intensive crops, such as fodder (which is cut green and fed to cattle, and needs daily commuting between the stable and the fields), vegetables and orchards (which need surveillance against birds and pilferers as well as need more attention of the farmer), are grown close to the farmhouse. They are followed by sugarcane and cotton. On the farthest fields, extensive crops, such as pulses, oilseeds, jowar, etc. are grown.

II. The villages Land use From the study of the land use statistics in Table 12.3, the following points emerge:

(i) The percentage of cultivation is high in all three villages (about 90 per cent of the total area), exhibiting high pressure of population on land. The percentage of cultivated area to total area is relatively higher in the uninhabited rainfed village of Chak Alam (Table 12.3) and lower in the intensively irrigated village of Khambra. This is due to the fact that more land is under community use in the form of graveyards, ponds, roads and habitation, in the latter.

(ii) The share of non-agricultural land is under 10 per cent and most of it is under community uses. There is no further scope for areal extension of cultivation, as it has already reached saturation level.

(iii) Of the cultivated area, over 90 per cent is sown, leaving under 10 per cent as fallow. In fact, as expected, the share of fallow is highest in the rainfed Village 1 (10.4 per cent), followed by Village 2 (8.7 per cent), which is partially rainfed, and lowest in the irrigated Village 3 (6.2 per cent).

(iv) Consequent on the variations in area sown more than once, the intensity of cropping varies considerably from 165 per cent in the rainfed and uninhabited village, to 175 per cent in the partly rainfed village, to 210 per cent in the wholly irrigated village.

Cropping The cropping patterns in respect of all three villages are presented in Figures 12.4 and 12.5 and the statistics are given in Table 12.4. From the study of these figures and Table 12.4, the following points emerge:

TABLE 12.3 VILLAGE LAND USE PATTERNS, 1968-69

(acres)

	1 Chak Alam	2 Alipur	3 Khambra
Total area	134	384	723
Cultivated area (cropland)	125 (93.3)[x]	346 (90.1)[x]	640 (88.5)[x]
Non-agricultural land	9 (6.7)[x]	38 (9.9)[x]	83 (11.5)[x]
Net sown area	112 (89.6)[xx]	316 (91.3)[xx]	600 (93.6)[xx]
Current fallow	13 (10.4)[xx]	30 (8.7)[xx]	40 (6.2)[xx]
Area sown more than once	73 (65.2)[xxx]	237 (75.0)[xxx]	660 (110.0)[xxx]
Total cropped area	185 (165.2)[xxx]	553 (175.0)[xxx]	1,260 (210.0)[xxx]

Note: Figures in brackets are percentages

[x] Per cent of the total area

[xx] Per cent of the cultivated area

[xxx] Per cent of the net sown area

Source: Field work and Revenue records

(i) Food crops dominate in the cropping patterns of all three villages, though their share in the total cropping varies considerably. In the rainfed uninhabited village, food crops (food cereals and food pulses and vegetables) constitute about 95 per cent of the cropped area, while in the other two villages with irrigated farming, the food crops share over half of the cropped area.

Wheat is the leading crop with three-fifths, two fifths and one third of the cropped area in respect of Villages 1, 2 and 3 respectively. While rice is the second leading food crop in Village 1, sharing one third of the cropped area, in Villages 2 and 3, maize takes the place of rice sharing less than 10 per cent of the cropped area. Rice is not significantly grown in Villages 2 and 3. In the irrigated Village 3, vegetables constitute over 5 per cent of the cropped area, while in the case of Village 2, it is less than 1 per cent and is completely missing in Village 1.

(ii) The cash crops rank high in irrigated villages. They share 25 and 29 per cent of the cropped area in the case of Villages 2 and 3, while in the case of 1, they share only 3 per cent. Among cash crops, potatoes rank first, followed by oilseeds, cotton and sugarcane. With irrigation facilities, potatoes are gaining importance. In Village 3, they share 16 per cent, in Village 2, over 11 per cent of the cropped area. In the case of Village 1, potatoes are missing as irrigation is not available and the soils are not suited to the crop. Oilseeds also share significant acreage in Villages 2 and 3. The sandy soils are suitable for the cultivation of groundnuts. Secondly, recently the prices of groundnuts had been very high and hence farmers make a larger profit by putting in least effort in the cultivation of groundnuts.

(iii) Fodder crops remain very important in the region. Fodder shares 15 per cent and 16 per cent respectively in Villages 2 and 3, which gives

TABLE 12.4 VILLAGE CROPPING PATTERN, 1968-69

Crops	1. Chak Alam Acreage	Per cent of cropped area	2. Alipur Acreage	Per cent of cropped area	3. Khambra Acreage	Per cent of cropped area
Food cereals:	175	94.6	285	51.6	582	46.2
Wheat	108	58.4	220	39.8	417	33.1
Rice	60	32.4	7	1.3	10	0.8
Maize	5	2.7	43	7.8	130	10.3
Others	2	1.0	10	1.8	25	2.0
Food pulses and vegetables:	-	-	5	0.9	65	5.1
Cash crops:	5	2.7	141	25.5	366	29.0
Potatoes	-	-	63	11.4	202	16.0
Oilseeds (Groundnuts)	-	-	54	9.8	86	6.8
Sugarcane	2	1.0	17	3.0	40	3.2
Cotton	3	1.6	7	1.3	38	3.0
Fodder crops:	5	2.7	82	14.8	207	16.4
Others:	-	-	33	6.0	-	-
Total	185	100	541	97.9	1,220	96.8

Note: The total is not 100 per cent as sugarcane standing crop and some other very minor crops are not included

Source: Field work and Revenue records

fodder the second rank in the general rank order of the crops. In the rainfed and uninhabited village, fodder shares only under 3 per cent - which is obvious from the fact that the fodder crop is not in demand as the village is uninhabited and transporting of fodder to far off places is difficult and uneconomical.

In conclusion, the following points can be made:

(i) Although the land use patterns do not deviate much in all three villages with different locations, it is the cropping patterns which vary considerably. In the irrigated villages there is a larger variety of crops than in the rainfed village. Not only the range of choice of crops differ significantly in different locations described above, but there is also a significant difference in the intensity of cropping.

(ii) In the irrigated villages, commercial crops rank high and share significant acreage. The crops such as potatoes, which were an introduction of the late 1960's in Punjab agriculture, are gaining importance.

(iii) There is a larger variety of crops which are grown in <u>kharif</u> cropping season than the <u>rabi</u>, though both crop seasons share equally the acreage under crops. This tendency is mainly in irrigated farming areas. In the rainfed areas, on the other hand, <u>rabi</u> crops share overwhelmingly.

(iv) The spatial pattern of cropping in irrigated villages suggests high intensity in the nearer fields as compared to the fields farther away.

SECTION 2: ZONING OF LAND USE AND CROPPING

The concentric rings of land use or cropping around rural settlements may arise from the basic principles governing the location of agricultural activities (Chisholm, 1969; Morgan, 1969). In the geographic literature, there is ample evidence for such an arrangement of land use in many parts of the world (Steel, 1947; Ahmed, 1952; Prothero, 1957; Waibel, 1958; Chisholm, 1969; Morgan, 1969; Blaikie, 1971), especially in the case of peasant societies where the distances between the fields and the settlements may be large, access to the fields difficult and through mud tracks, and where these distances have to be travelled regularly and mostly on foot (for more details, W.B. Morgan, 1969).

In India too, such land use and cropping zones may occur (Ahmed, 1952; Blaikie, 1971) but they seem largely to be in areas where rural settlements are nucleated and large, population sparse and irrigation rare. They may also occur around major urban markets where the influence of urban market is significant. In the context of the present study area, these patterns seem to have weakened considerably on account of long established cultivation, dense population, (which causes dispersal of settlements in the form of small villages and consequently reduces distances between the settlements) and intensive irrigation. Here the vital factor governing the land use and cropping remains largely water (Blaikie, 1971), though distance exerts its control significantly in various other ways, as will emerge below.

Moreover, the farms have been consolidated and the farmers own their farms in different locations within the field boundaries of the village. Since the holdings are small and the pressure of population on land is high, the share of waste land, in any form, and fallow lands is negligible, a fact not consistent with the requirements of any such zoning (Morgan, 1969, suggests that a considerable area in waste, woodland, forests and fallow is desired for the optimum development of land use rings). Furthermore, due to the subsistence nature of farming, the farmer aims at overall self-sufficiency in his household consumptions to meet his obligations of food for the family and fodder for livestock. This results in a large variation in agricultural practices and cropping which is reflected in their cropping patterns (supra, Figs. 12.1, 12.2, 12.4 and 12.5). In these circumstances, the efforts of the farmer are to maximise his output from his small holding, irrespective of the location of the farm.

Against this background, it was thought that the zoning of crops or land use around rural settlements, in the present context may not be a valid hypothesis. However, from the study of land use maps, there seems to be a tendency towards (a) a decline in intensity of land use with the increase in distance from the centre of farming operations - farmhouse or village settlement, and (b) occurrence of zoning of commercial crops around urban market. It is these two aspects which will now be investigated.

A. The intensity pattern and rural settlement

The tendency of decline in intensity of land use with increasing distance from the centre of farming operations may be attributed to input as well as output factors in the present context. Among the input factors, the most important factor giving rise to zoning of intensity is the use of manure, which varies considerably with the increase in distance from the centre of farming operations. Livestock is stall-fed and kept mainly within the village core. The manure is collected and later transported to the fields in carts at the time when labour is in demand for other farming operations. Rough mud tracks make the cartage of manure to the farther fields much more difficult, if not impossible. Moreover, the livestock are allowed to wander during the periods of the year when there are no growing crops, and this provides extra manure to the nearer fields.

Labour, both human and animal, operates from the centre of farming operations, which means a considerable time lapse and waste of energy in travelling to and from the fields for most of the time of the year. Implements, seeds and fertilzers must also be carried out to the fields. Equally important is the protection of crops in the fields from animals and pilferers which needs more time and effort on the part of the farmer, whose fields are farther away from settlement than those whose fields are nearby. Therefore it follows that the fields closer to the settlement are more heavily and frequently manured, better protected, and consequently more intensively cultivated than the fields farther away.

Well and tube-well irrigation (which shares a larger proportion of irrigated area in the region) is also closely related to the distance from the farmhouse and from the village. The spatial distribution of wells and tube-wells supports this argument. This is mainly due to two factors. First, on account of higher fertility due to heavy manuring, the use of irrigation can be more profitable in the nearer fields than the fields at a larger distance. Secondly, there is the advantage of safety of irrigation installations. The distance factor affects canal irrigation as well, but in a different way irrespective of the location of the village as such. The quality of irrigation service generally deteriorates with increasing distance from the inlet of the major channel and the order of the channel. On account of the advantages described, the returns from the nearer fields are relatively higher and hence there are more chances of intensive cultivation in the nearer fields.

Among the output factors, distance in terms of transport is more valid than any other factor. The transport-intensive crops such as fodder, vegetables, potatoes, sugarcane are generally favoured near the settlements. Fodder, which is cut green and fed to the stock, needs almost daily commuting. To save this commuting time to the minimum possible and for the sake of convenience, it has to be preferably grown near the settlement so far as possible. Vegetables which need special care and protection against birds and pilferers, are also grown in the nearer fields. Sugarcane is a transport and labour-intensive crop and hence is grown in the nearer fields.

Crops such as wheat, barley, gram, oilseeds are generally gathered after harvest near the village core for the threshing purposes. This is mainly due to two things. First, after the crop is harvested, it needs protection against pilferers. Second, where the mechanical threshers are used for threshing, they are located close to the village core for both easy availability of power and greater security. Moreover, it is also convenient and advantageous to transport a crop from the fields near the village core than transporting a crop in the form of grain and chaff (Bhussa), because ultimately the chaff as well as the grain (most of it) is to be stored within the village core.

On account of manifold advantages of the fields closer to the settlements, there is a strong tendency among the farmers to own or rent a piece of land close to the village boundary. This leads to higher land values and rents for these fields. In many cases, it could be as high as 2-4 times the normal land values/rents (personal observation).

Zoning of intensity From the premises described, a simple model of intensity of land use can be constructed. It follows that the pattern of zoning of higher intensity develops from the centre of farming operations and declines as it moves away from the centre. This may be described as a modified form of Von Thunen's theory of intensity.

Crop data were collected for each field for the three agricultural years (six harvests) - rabi, 1966-67 to kharif, 1968-69, in respect of three villages and two farms. Each village and farm was divided into several concentric zones (at an interval of 100 metres) around the settlement and their boundaries were adjusted to suit the field patterns. The total number of fields (a complete acre was considered and taken as a unit) in each zone was counted. Some minor crops were eliminated. General planting frequencies were calculated by employing simple procedures for each of the crops in each zone. The number of acres under each crop was multiplied by the average man days required to produce that crop (supra, Appendix II), and divided by 3 to obtain the total units in man days per zone per year. This was further divided by the number of units (acres) in each zone to achieve the weighted value per unit of area per year for each zone.

The results were plotted and simple regression techniques were used to test the significance of distance factor related to intensity patterns (Fig. 12.7). This was found to be highly significant (significant at 1 per cent level) in respect of Villages 2 and 3. The analysis in the case of these two villages was extended further to test if they are significantly different from each other. 95 per cent confidence levels were calculated and are given below:

Village	Slope	Standard error	Confidence intervals	
2	-0.063	$\pm$0.0041	-0.0533,	-0.0727
3	-0.033	$\pm$0.0015	-0.0297,	-0.0363

As these confidence intervals do not overlap each other, these slopes differ significantly at 5 per cent level. They also suggest that intensity declines more rapidly with distance in Village 2, which is partly rainfed. This was, however, expected. In the case of Village 1, as expected, the regression was not significant. In the case of Farm 1 also the regression of distance and intensity was highly significant (1 per cent level).

On the basis of these analyses, the final zoning was then achieved and the results thus obtained are plotted in Figures 12.3 and 12.6 and listed in

Table 12.5.

TABLE 12.5 FARM AND VILLAGE INTENSITY OF LAND USE PATTERNS

Farms

Zones	Farm 1		Farm 2	
	Distance in kilometres	Intensity per acre in man days	Distance in kilometres	Intensity per acre in man days
I	Under 0.25	100	Under 0.50	70
II	0.25 - 0.50	90	1.50 - 2.00	60
III	0.50 - 0.75	65	2.00 - 2.50	40
IV	Over 0.75	40	-	-

Villages

Zones	Village 1		Village 2		Village 3	
	Distance in kilometres	Intensity per acre in man days	Distance in kilometres	Intensity per acre in man days	Distance in kilometres	Intensity per acre in man days
I	Under 1.75	45	Under 0.25	70	Under 0.25	85
II	1.75 - 2.00	40	0.25 - 0.50	55	0.25 - 0.50	75
III	2.00 - 2.25	50	0.50 - 0.75	35	0.50 - 0.75	65
IV	Over 2.25	40	Over 0.75	25	0.75 - 1.00	60
V	-	-	-	-	Over 1.00	55

From the preceding analysis, the following points emerge:

(i) The intensity of land use decreases significantly with increasing distance from the centre of farming operations.

(ii) The distance factor is more important in the unirrigated area than the irrigated one.

(iii) The intensity is higher in the irrigated areas than the rainfed areas, and the difference between the two is considerable.

B. The cropping pattern and the urban market

The occurrence of zoning of crops around urban markets may be attributed to many factors. Among them the most important is the demand from the urban population for specialised services such as milk, vegetables, fruits, food and fodder. In the developing societies, urban centres constitute the main destinations of much of the agricultural produce and the source of many farming requirements such as fertilizers, seeds, pesticides, capital, machinery and other specialised services.

The urban centres provide a considerable amount of manure from the sewerage and street sweepings. Most of the dairy cattle are kept in and around the city and since the cattle are stall-fed, they provide a plentiful supply of manure. This manure is generally used in the fields surrounding the cities as it may not be worth carrying very far. The urban centres are also the source of much casual labour required for various operations in growing labour and transport-intensive crops. Since these crops fetch better prices and the returns to the farmers are correspondingly high, the capacity of the farmer to invest more in terms of inputs increases. This factor gives rise to higher intensity in the fields close to the city than the fields far away.

The means of transportation are not efficient and the refrigeration facilities are rare. Therefore, certain highly perishable crops, such as vegetables, fruits, dairy produce and transport-intensive crops such as potatoes, sugarcane and fodder, cannot be transported safely and easily very far, and tend to be produced near the markets, whereas, the other products such as food cereals are more prominent in areas further away. Wherever storage facilities are available, they tend to be near the urban market, where transport and power facilities are easily available and more dependable. Hence, this is a special advantage to the farmers whose lands are near the market

TABLE 12.6 CHI-SQUARED TESTS FOR SINGLE CROPS, VILLAGES OF RERU AND NOORPUR

	Zones:	I	II	III	IV	V	VI
	Distances (kilometres)	Under 0.50	0.50-1.00	1.00-1.50	1.50-2.00	2.00-2.50	Over 2.50
Vegetables							
	Frequency observed	16	200	119	90	51	13
	Frequency expected	3	49	126	168	105	38
		Chi-squared value 602.3		Significant at 99.5 per cent level			
Potatoes							
	Frequency observed	3	42	194	229	121	36
	Frequency expected	3	63	161	214	134	49
		Chi-squared value 25.5		Significant at 99.5 per cent level			
Fodder							
	Frequency observed	4	94	332	289	117	43
	Frequency expected	5	89	227	301	189	68
		Chi-squared value 86.2		Significant at 99.5 per cent level			
Sugarcane							
	Frequency observed	-	7	48	105	53	14
	Frequency expected	1	23	59	78	49	18
		Chi-squared value 23.9		Significant at 99.5 per cent level			
Cotton							
	Frequency observed	-	7	57	86	41	15
	Frequency expected	1	21	53	71	44	16
		Chi-squared value 14.0		Significant at 95 per cent level			
Wheat							
	Frequency observed	-	30	185	344	203	97
	Frequency expected	5	86	222	294	185	67
		Chi-squared value 71.2		Significant at 99.5 per cent level			
Maize							
	Frequency observed	-	23	86	136	152	51
	Frequency expected	2	45	116	153	96	35
		Chi-squared value 61.9		Significant at 99.5 per cent level			

and further enhances their chances of growing cash crops.

The combination of these factors, in turn, produces a zonal pattern of commercial cropping around the main market. This will now be investigated.

Zoning of cropping From the premises described, a simple model of cropping can be erected. It states that the highly perishable, labour, transport and capital-intensive crops tend to be produced near the main market, whereas, the other products are more prominent in areas farther away. This may be recognised as a modified version of Von Thunen's theory of crop zoning.

Method The data were collected in the same way as was done in the case of the first set of villages. The location of the villages has already been described. The fields of both the villages were divided into six zones at an interval of 0.50 kilometres from the municipal boundary of the city of Jullundur. A chi-squared test was used to determine whether the major crops were grown in a significantly different distribution from one that would be expected if the crops were grown proportionately in all zones. Seven major crops were included in the analysis and they are vegetables, potatoes, fodder, wheat, maize, sugarcane and cotton. The results of the test are shown in Table 12.6.

A chi-squared test was selected because it is the most powerful test for this type of analysis. Moreover, the necessary conditions for its use were satisfied by the data (for more details, supra, B. Mitchell, 1971). The analyses were extended further in order to obtain the rank ordering of crops for each zone. This was achieved on the basis of relative divergence of observed and expected frequencies ($o_i - e_i$)/e_i for each crop in each zone. The results thus obtained, give a clear picture of the strength of each crop in each zone and the association of crops in each zone, and are presented in Table 12.7.

TABLE 12.7 RANK ORDER OF CROPS IN DIFFERENT ZONES

	Very strong	Strong	Moderate	Weak	Very weak	Almost absent
I	Vegetables			Fodder		Wheat Maize Potatoes Sugarcane Cotton
II		Vegetables Fodder			Wheat Maize Potatoes Sugarcane Cotton	
III	Potatoes Fodder	Cotton	Vegetables Sugarcane	Wheat Maize		
IV	Wheat Sugarcane Cotton	Potatoes	Maize	Vegetables Fodder		
V	Maize	Wheat Sugarcane	Potatoes	Cotton	Fodder Vegetables	
VI		Maize	Wheat	Sugarcane Potatoes	Cotton	Fodder Vegetables

Results The following results were obtained from the analyses:

(i) The chi-squared values show that the major crops are grown in a significantly different distribution from one that would be expected if the crops were grown proportionately in all zones.

(ii) Certain crops are strongly present in certain zones and almost absent in others (Table 12.7).

(iii) The association of crops with zones can be summarised as under:

Zone I Vegetables (very strong), fodder (weak)

Zone II Vegetables (strong), fodder (strong)

Zone III Potatoes (very strong), fodder (very strong)

Zone IV Wheat (very strong), sugarcane (very strong), cotton (very strong)

Zone V   Maize (very strong), wheat (strong), sugarcane (strong)

Zone VI   Maize (strong), wheat (moderate)

(iv) The order of crops with increasing distance is: Vegetables, potatoes, fodder, sugarcane, maize and wheat.

CONCLUSIONS

The following conclusions can be drawn. Ecological environment may limit the range of crops, but socio-economic factors determine which of the feasible crops the farmer will choose and the input intensity with which he farms. Irrigation not only increases the range and choice of ecologically feasible crops on a farm but also, raises the practicability or profitability levels of input intensity. The intensity of land use and cropping is significantly related to distance and irrigation. The intensity of land use decreases significantly with increasing distance from the centre of farming operations, though the distance factors are more crucial and limiting in the rain-fed areas than the irrigated ones. The intensity of land use is considerably high in the irrigated lands. Urban market influences and modifies rural land use significantly. The crops which are highly perishable, labour, transport and capital-intensive are grown near the urban markets. Given the same ecological environments, a different cropping pattern may emerge as a consequence of difference in the perceptions of the individual farmers, as depicted in the case study of two farms. The present analyses confirm the findings outlined in the preceding chapters (8 - 11).

CHAPTER 13

THE SYNTHESIS OF EMERGING CROPPING PATTERNS

A detailed account of the emerging patterns of cropping is presented in the foregoing pages, and the broad conclusions drawn from them have been reinforced in the case studies. The aim of this chapter is to provide a synthesis of these patterns. This is attempted through the examination of the competitive acreage-strengths of the crops; the localisation of crops; and finally by the delineation of crop pattern regions.

Ranking of crops

It is useful to start with the ranking of crops. This helps to bring out a clearer spatial picture of the relative status of the crops; to seek inter-crop and intra-crop spatial levels of importance; and finally and more importantly leads to a greater understanding, and therefore a more critical assessment of the ensuing composite patterns of crop pattern regions.

The examination of the competitive strengths of crops has been carried out by analysing crop-acreage rank order of twelve leading crops which jointly account for 96 per cent of the total harvested area of the Doab. The acreage devoted to each crop was arrayed in a descending magnitude for each of the individual areal components, 360 sample villages, and then studies together with those which attain the same rank. In Figure 13.1 to 13.5 the first, second, third, fourth and fifth most important crops have been represented by non-quantitative geometric symbols. Each crop has been allocated a symbol, but wherever the respective crop attains a significant level, the symbol is encircled. This level was fixed by examination of the frequency distribution patterns of the ranking crops. In the first and second ranking crops, this level approaches the upper quartile while in the third, fourth and fifth, it is a compromise between the frequency distribution pattern and the upper quartile limit. For example, in Figure 13.1, this level is 40 per cent of the harvested acreage. Wherever the first ranking crops account for more than 40 per cent, their respective symbols are encircled. The same procedure is adopted in respect of other ranks.

First ranking crops Figure 13.1 shows that seven crops rank first. As expected, major grains - wheat, wheat/gram, maize and rice - dominate, accounting for about 90 per cent of the total occurrences. Amongst foodgrains, however, the supremacy of wheat is evidently established from the fact that wheat alone accounts for over 56 per cent of the total occurrences in the first rank order. The non-foodgrains include oilseeds, fodders and vegetables. Though their relative position in terms of frequency distribution is weaker than that of foodgrains, their appearance at this stage in itself is highly meaningful.

The distribution of the first ranking crops is clearly defined. Wheat, the crop which appears most frequently in the first place, is clearly dominant in the irrigated parts of the loamy soils in the plains. Spatially, it covers Jullundur and Kapurthala districts, with the exception of Dona tracts and some areas near urban centres; major parts of Dasuya tahsil except Maira; parts of Sirwal and Kandi of Hoshiarpur; and parts of Bet and Sirwal of Garhshanker. In the drier parts of the hills, wheat/gram ranks first, largely confined to Sirwal, Kandi and Rakkar of Hoshiarpur district. The non-foodgrains, on the contrary, tend to show localised distribution. Both vegetables and fodders appear as first ranking crops near the urban centres, emphasizing their close association with the urban markets. Oilseeds appear as first ranking crop in Dona tract of the Doab which may be attributed to the ecological requirements of groundnuts in the tract.

Each of the first ranking crops exhibit diversity in their harvested acreage occupied by a crop and by the corresponding first ranking crops. For example, wheat appears more strongly, occupying over 40 per cent of the harvested acreage, in Bet areas; parts of Kandi and Rakkar of Dasuya; and Manjki of Phagwara. Elsewhere, the crop occupies less than/up to 40 per cent of the harvest. Similarly, wheat/gram exceeds 40 per cent limit in Kandi tracts; maize in Rakkar of Dasuya; and rice in Maira of Dasuya, Bet of Kapurthala and Dhak of Nawanshahr. Among non-foodgrains, only oilseeds exceed 40 per cent in Dona of Nakodar and parts of Dona of Kapurthala.

Second ranking crops The only additional crop to enter the list at this rank is gram; and its significance is very small (Fig. 13.2). However, the frequency and spatial incidence of crops has largely been transformed. Wheat, the most widespread crop in the first rank order declines to third position in the frequency distribution and is for the large part displaced by fodders; in the drier parts by maize and in Bet areas by rice. Where rice was first crop, wheat almost always ranks second. Wheat and wheat/gram occurred in the second place where maize and oilseeds were first. Vegetables too have been replaced by fodders.

The dominance of foodgrains is sustained, accounting for two thirds of the total occurrences (Table 13.1). But it is fodder which appears more frequently and is localised around urban centres. Maize, with the highest frequency distribution among cereals, is largely concentrated in the rainfed parts. Its acreage-strength is higher, over 25 per cent of the harvest, in parts of Kandi, Sirwal and Bet areas. Wheat follows maize and largely accounts for over 25 per cent of the harvest. Wheat/gram seldom exceeds 25 per cent level. Rice occurs in Bet areas of Kapurthala and Dasuya tahsils and it nowhere exceeds 25 per cent of the harvest. Gram, oilseeds and vegetables show very patchy and limited distribution at this stage.

Third ranking crops The map of third ranking crops is a mosaic of ten different crops (Fig. 13.3). The additional crops at this rank are sugarcane and pulses. The areal pattern is somewhat fragmented but the map reveals the relative importance of sugarcane in the local ecology and also indicate its spatial association with the processing centres. With the decline in rank order, the spatial shift of vegetables from major urban centres to minor ones is another significant development. Fodders and maize almost maintain their frequency distribution strengths from second to third rank but spatially have replaced each other. Similarly, wheat and wheat/gram have interchanged their locations. Fodders attain maximum spatial coverage as a third ranking crop, accounting for 38 per cent of the occurrences. With the exception of degraded lands, they appear throughout the Doab.

Fourth ranking crops All the twelve crops enter into the fourth rank order and as is to be expected, present a much fragmented distribution (Fig. 13.4). Jointly, wheat/gram, maize, fodders and sugarcane account for 73 per cent of the total occurrences at this stage. The late appearance of cotton and barley is a clear reflection of their low importance in the local agricultural economy of the Doab.

The important feature which emerges here is the appearance of particular cash crops as a significant group, accounting for 23 per cent of the total occurrences. Foodgrains maintain their supermacy, but among them, wheat/gram and maize appear more frequently. Wheat, the most important crop of the region, is persistently declining in its frequency distribution (Table 13.2). Rice totals as much as wheat and presents a distribution almost opposite to that of wheat.

TABLE 13.1 RANKING STATUS AND PERCENTILE FREQUENCY DISTRIBUTION OF VARIOUS GROUPS OF CROPS, 1966-68

Rank	Foodgrains	Fodders	Cash crops
First	89.4	5.3	4.7
Second	66.1	32.8	0.8
Third	57.5	37.8	3.9
Fourth	59.6	16.4	22.9
Fifth	48.7	4.7	43.8

Fifth ranking crops Three crops dominate in the fifth rank order (Fig. 13.5). Among them, sugarcane appears most frequently. The other two include wheat/gram and rice, each accounting for about 15 per cent. It is interesting, however, that all the cash crops as well as vegetables attain their highest frequency distribution in the fifth rank order (Table 13.2), suggesting that they pleyed a far less important role in the economy in the past than the foodgrains, which achieved higher frequencies in higher rankings.

Spatially, almost all crops tend to show highly fragmentary distribution, with the exception of vegetables which have consistently shown localised

TABLE 13.2 RANKING STATUS AND PERCENTILE FREQUENCY DISTRIBUTION OF IMPORTANT CROPS, 1966-68

	Food cereals				Cash crops			Others
Rank	Wheat	Wheat/gram	Rice	Maize	Sugarcane	Oilseeds	Cotton	Vegetables
First	56.1	14.7	8.9	9.7	-	4.7	-	0.6
Second	18.6	12.2	8.6	26.4	-	0.8	-	0.3
Third	11.7	12.8	3.6	25.5	1.9	2.0	-	0.8
Fourth	6.6	20.8	5.8	19.7	15.6	4.2	3.1	1.1
Fifth	3.0	15.6	14.2	7.8	31.1	5.8	6.9	2.8

distribution. Sugarcane, the crop which appears most frequently, is largely confined to areas which are well within the commuting distances from the processing centres. The areal distribution of wheat and wheat/gram remains similar to that of the fourth order. Cotton occurs largely in southern parts where its ecological conditions are better met.

Localisation of specialised crops

Throughout the preceding discussion, some crops have persistently exhibited localised patterns. The association of sugarcane with the processing centres, the tendency of fodders to appear more significantly near urban centres, the highly localised distribution of vegetables around major markets, all lend support to the existence of localised patterns. These localised patterns stem from the uneven distribution of the factors of production, the physical and social attributes of location and the impact of markets.

The aspects of localisation have been discussed elsewhere (Chapter 12), but it will be useful to recall and restate, in part, the reasons particularly those which are basic to these patterns and which link up the factors of production with those of consumption. Urban centres constitute the main destinations of a substantial amount of agricultural produce, and are the source of many farming inputs. The means of transport are inadequate and inefficient. Consequently, transporting bulky and perishable produce long distances is both time consuming and uneconomical. Stall-fed milch cattle are provided with fodder which is too bulky to be transported long distances. Moreover, stall-fed cattle supply manure and street sweepings in large quantities, which have to be removed but which are not worth carrying very far. Equally important is the diffusion effect of new seeds, new farming techniques and new farm implements which diverge from these centres. The 'gentlemen farmers' of the cities, who own farms in the immediate surroundings, have the resources and entrepreneurial ability to grow capital-intensive specialised crops, which in turn yield higher profits. It is, therefore, useful to examine more closely these patterns presented by specialised crops.

The rank order of vegetables is presented in Figure 13.6. This clearly demonstrates the localised distribution of vegetables around major urban centres. The spatial distribution, however, exhibits two distinct tendencies: (i) a general 'distance decay' tendency, whereby the rank order status of vegetables declines with the increasing distances from the urban markets; and (ii) a strong relationship between the size of the market and the intensity of vegetable cultivation. The larger the market, the higher the intensity of vegetable cropping. For example, Jullundur and Hoshiarpur are the two large markets and there exists a substantial demand for vegetables; consequently they appear as first ranking crops in the cropping assemblage around these towns. While around towns of lesser economic importance, such as Garhshanker, Nawanshahr and others, the rank of vegetables is much lower.

Fodders, to a great extent, are complementary to vegetables for two reasons. Firstly, farmers growing vegetables on a commercial scale are usually dairy farmers as well. Milch stock are normally kept to supplement incomes and as an insurance against natural and economic hazards. Secondly, there is an ecological advantage in growing vegetables and fodders in rotation, which conserves soil fertility. Despite the ubiquity of fodders at different rankings in the cropping assemblage, their rank order distribution (Fig. 13.7), suggests a two-fold relationship. Firstly, they tend to show a higher concentration near urban centres and in areas of higher livestock intensity. Secondly, like vegetables, fodders decline in rank order status with the increasing distances from the market centres.

Two more points may be made here which will help in explaining the two significant concentrations around Jullundur and Hoshiarpur towns. Jullundur town is the largest urban centre of the Doab (third largest of Punjab). It supports a population of over 265,000 (including the cantonnment) and is a large industrial town, providing agricultural infra-structure. It serves as a focus for inter and intra-regional trade and commerce, and is linked up with a good rail and road network. It not only provides a large local market for specialised crops but also acts as a feeding centre for other small towns of the area. Hoshiarpur, on the other hand, has been traditionally a centre for hill towns of the north-east. The availability of inexpensive labour from the economically backward hill-areas further enhanced the growing of intensive crops such as vegetables in the past.

Sugarcane is a special case, subject to State legislation. The government has the power to designate a specific area around a sugar mill as an official 'mill area' (normally the areas within 10 miles radius) and to fix the price of cane that the mill will pay. All the farmers growing cane within such a zone are obliged to sell it to the mill. However, to promote the cultivation of sugarcane, various subsidies and special loan schemes are introduced, from time to time, to ensure procurement of sugarcane for the mill. These factors, in combination with others, especially distance and perishability, obviously result in localised patterns of sugarcane around the processing centres. This is evident in Figure 13.8.

From the study of Figure 13.8, two points emerge:

(i) The cultivation of sugarcane is closely associated with the processing centres and with the road and rail networks - the 'effective zone' of the mills. Outside these zones, sugarcane has only minor importance for domestic uses.

(ii) There is a general distance decay trend; that is, the rank status declines with the increasing distances from the processing centres.

Crop pattern regions

The crop pattern regions are established by applying a hierarchical grouping algorithm developed by Ward (1963) and later applied by Berry (1967), Spence (1968) and others to a number of regionalisation and classification problems in geography. A review and extensive bibliography on the subject is given by Spence and Taylor (1970). In the context of agricultural geography, however, particular reference must be made to the studies carried out by Cowan and Lovingood (1970, 1972), Aitchison (1972) and Anderson (1974).

The choice of the method stems from two considerations: (i) the impracticability and failure of Weaver's deviation model; and (ii) the superiority and suitability of an hierarchical grouping algorithm in the present context. These two considerations demand elaboration.

Weaver's model The grouping of crops into crop combination regions was first attempted by Weaver (1954), who used a standard deviation formula for delineating the crop combination regions of the American Middle West. It may be noted initially that it was here applied to an area with one main growing season a year; the circumstances of the monsoonal lands with two major cropping seasons inevitably present complications, or the necessity for arbitrary simplifications. Furthermore, a major concern of this thesis is change over time, and it is desirable to seek a method of presenting crop pattern regions that can be held consistent as time proceeds. Weaver devised a standard curve against which variations could be measured. All the crops which showed minimum deviation from the standard value were included in the crop combination region. This model was later widely used, largely in modified form, by many geographers. Reference may be made to the works of Scott (1957), Thomas (1959, 1963), Bennet (1961), Coppock (1964), Grigg (1966), Clout (1967) and Uzozie (1971). In the context of Punjab (India), the studies carried out by Singh (1965) and Singh (1967) may be cited.

The experience gained from these studies has shown that to achieve the desired crop combinations, many subjective and arbitrary choices were made at various stages of the analysis. For example, Scott (1957) in his study 'The agricultural regions of Tasmania: a statistical definition' used data only for seven crops (he excluded 4 crops - 3 speciality crops and barley) for 105 districts. He ignored the rank order completely, admitting that

> The retention of the ranked letter combination, however, would have yielded a pattern far too complex and far too fragmented for portrayal cartographically ...; the number of basic combinations would have been 51 compared with 22 ...

Even after all these subjective generalisations he states that the map of crop combination regions is '...bewildering; the map neither defines major regions nor permits the definition of a hierarchy of subregions'.

Singh (1967) claims that his work is based on village level data. But for the purposes of delineating crop combination regions, he used aggregative data of assessment circles, 19 of them, without giving any justification. Moreover, he included only primary and secondary crops in the analysis and maintained rank order only partially. He ended up with 8 crop combination regions. Uzozie (1971) worked on village level data. He included crop statistics of 147 sample villages. He ignored the rank order completely and ended up with 26 crop combinations. After achieving these he admits that 'It therefore became necessary to recognise only the standard food crops', 6 of them, which finally rescued him to end up with 9 crop combination regions.

The present study has also been carried out on village level. The statistics of 12 crops for 360 sample villages were used to test the feasibility of Weaver's model. The result was the emergence of 153 crop combinations. When rank order was completely ignored, the number was reduced to 59. These are listed in Appendix III. Therefore, it was concluded that Weaver's model in village agriculture of India is not feasible. A similar conclusion was achieved by Panda and Saxena (1972) in their study 'Crop combination regions of Chhatisgarh Basin in India'.

<u>Ward's hierarchical grouping algorithm</u> The algorithm operates by computing a measure of similarity between every pair of objects, in this case the areal units (sample villages). It combines the two most similar units and recomputes the similarities for the newly created 'object' with the rest. The process is repeated through a series of steps until eventually only one group, containing all the

observations, exists. The results thus achieved can be represented in a tree diagram or dendrogram which shows the grouping sequence plotted against the similarity level of each combination.

Merits The method is useful in many ways:

(i) It takes into account the whole complex of crops. In this case 12 crops for each of the 360 sample villages were included. The percentage of harvested acreage under each crop was computed and used which gave a weighted value for each of the crops. Moreover, the presence of a crop is as important a consideration as the absence, in allocating an individual to a group. For example, vegetables remain unimportant in the region as a whole but form a significant proportion of the cropping assemblage around urban market centres. This feature has been clearly revealed in this classification. The model also provides additional information about the crops which are significantly absent or significantly present in a region. Weaver's model, on the contrary, is highly dependent on the dominant crops and does not provide any further information about the minor crops.

(ii) The method is relatively more objective because it utilises all the information contained in the data and without imposing *a priori* judgement. Weaver imposes his theoretical model on the data.

(iii) The method uses a defined numeric measure of similarity which is applied uniformly to all the units. It therefore satisfies the criterion of replicability.

(iv) The method offers a choice in selecting the desired groups at a level. The sub-optimal groups, if any, can be re-allocated by using an optimisation algorithm. Furthermore, it provided summary statistics for each group, which helps considerably in understanding and making meaningful interpretation of the regions.

(v) Equally important is the suitability of the method in the present context. It provides very meaningful results.

King (1969) compares Weaver's crop combination regions map for Ohio and the one he achieved by using the hierarchical grouping algorithm. He finds that 'Not only are the two maps remarkably similar, but the grouping algorithm produced quite contiguous regions. Besides it yields additional results which are not available in Weaver's study'. The superiority of hierarchical grouping algorithm over Weaver's has also been suggested by Cowan and Lovingood (1970).

Limitations General limitations of any statistical technique are imposed by the nature of the available data. The data used in this study has been discussed elsewhere (p. 9) and must for the present circumstances be accepted. The other limitations are:

(i) It does not, necessarily produce contiguous regions. This may contradict the claim of many geographers who consider that 'a region must consist of contiguous individuals otherwise a region will not be formed' (Grigg, 1965). There exists, it is true, certain algorithms where contiguous regions can be attained by imposing contiguity constraints. This, however, was not applied here for:

> These procedures appear to misrepresent reality to a greater extent than necessary for the production of useful generalization.
>
> ...regionalizing with contiguity constraints over-simplifies and operates against efficient hypothesis-testing.
>
> (Johnston, 1970)

Furthermore, the application of contiguity constraints leads to obscuring details which are essential. For example, in the present study, it was expected that the vegetables would appear around the major urban centres. If contiguity constraints are applied to the data set, obviously they would either disappear or occur over an unreal space.

(ii) No analytic solution exists for the problem of deciding how many groups are necessary. However, a careful study of the dendrogram with the summary statistics provide a reasonable insight as to how many groups are appropriate.

(iii) The use of Euclidean distance as a measure of similarity is arguable. But the extensive use of the measure in geographic research suggests that it is the most appropriate measure for the data used in the present study. Kendall (1971) suggests

> ...when we come to cluster a large number of individuals, the number of pairs of distances between them goes up rapidly as the square of the number of individuals, and in that context I would like to put in a strong plea for the use of the ordinary Euclidean metric, ...

(iv) There is a likelihood that the marginal points may be classified wrongly. However, any such errors can be eliminated through the use of optimisation techniques.

Procedure The percentage of harvested acreage devoted to each of the 12 crops included in the analysis was computed. This eliminated distortions due solely to size and focussed upon the relative significance of each crop in the total assemblage of cropping. Euclidean distance as a measure of similarity has been used. To perform the grouping the CLUSTAN program was used. This program was devised by Wishart (1969) and it embodies Ward's algorithm. No contiguity constraint was imposed. After thorough examination of the dendrogram resulting from grouping, ten groups were finally selected. These represent the most distinct regions. The spatial pattern of the final regions is presented in Figure 13.9, and a set of summary statistics is given in Table 13.3. To examine

TABLE 13.3 SUMMARY STATISTICS (MEAN PERCENTAGE VALUES) FOR CROP PATTERN REGIONS, BIST DOAB, 1966-68

Region	Frequency of occurrence	Wheat	Wheat/gram	Gram	Barley	Rice	Maize	Sugarcane	Cotton	Fodder	Pulses	Oilseeds	Vegetables
I. Rice	39 (10.8)	26.85	5.65	0.82	0.85	37.13	7.15	3.08	1.17	14.41	1.46	0.83	0.72
II. Wheat	17 (4.7)	55.62	7.96	1.17	0.06	2.15	5.82	1.63	1.32	14.19	1.40	1.33	2.38
III. Maize and wheat	22 (6.1)	44.57	4.82	0.29	0.19	2.81	31.93	2.24	0.84	6.71	1.84	1.27	0.32
IV. Rice and wheat	33 (9.2)	37.97	3.88	0.36	0.07	17.87	11.20	4.67	2.08	15.66	1.47	1.81	1.26
V. Wheat/gram and wheat	24 (6.7)	29.02	27.02	1.42	0.34	1.61	11.60	3.35	2.00	14.18	2.40	2.90	2.48
VI. Wheat/gram, maize and fodder	44 (12.2)	9.97	34.67	2.26	0.06	2.34	17.52	5.42	2.15	16.97	2.31	1.49	1.30
VII. Wheat, fodder and maize	91 (25.3)	33.22	6.50	1.15	0.06	3.27	16.79	6.30	3.36	20.47	1.56	3.56	1.55
VIII. Diversified	61 (17.0)	18.82	14.45	2.27	0.08	3.58	23.59	6.07	2.24	18.80	2.11	1.65	2.66
IX. Oilseeds	17 (4.7)	17.60	11.00	0.88	0.02	2.33	7.22	2.56	2.61	11.51	0.79	41.03	1.18
X. Vegetables	3 (0.8)	10.90	10.41	0.12	0.23	4.04	14.62	0.83	0.23	25.60	1.01	1.63	28.67
No cropping	9 (2.5)	-	-	-	-	-	-	-	-	-	-	-	-
Overall	360 (100)	27.40	12.37	1.28	0.10	7.90	15.64	4.61	2.18	16.21	1.77	3.90	1.79

Note: Figures in parentheses indicate percentages of frequencies the relationship between the regions, a multidimensional scaling (MDS) procedure was used. This is exhibited in Figure 13.10 and can profitably be used together with Table 13.3 to gain greater insight into the regions.

Before taking up the discussion of the individual regions, two points may be made. First, that in the absence of contiguity constraints, these regions present a fragmentary spatial pattern, but, nonetheless, there are still clear patterns in the distribution of the regions. These patterns reflect the complexity of cropping structure in the Doab and represent a synthesis of the general distribution of crops, the ranking of crops and the features exhibited by case studies. Secondly, it should be stressed that the labels of the regions are just short names, usually representing the most significant crops of the regions. Where more than one crop is involved in the label, the order of significance of the crops is maintained. For example, in the maize and wheat region (III), maize is the most significant crop and wheat is the second most significant. The regions have been labelled largely for the sake of convenience of referring to them in the text. The real nature of the regions, however, can fully be appreciated only by examining the whole complex of crops (Table 13.3). The sequence in which these regions are presented is a compromise between their frequency of occurrence, their relative significance and the convenience of their treatment.

<u>I. The rice region</u> The rice region accounts for 11 per cent of the total occurrences. Spatially, it is in two main parts. The larger concentration is in the old canal-irrigated tract of the north, comprising Bet and Maira of Dasuya and further projecting southwards into Kapurthala tahsil along Western <u>Bein</u>. The other, relatively smaller, area is a section of Dhak tract of the Doab, a low-lying area, along Eastern <u>Bein</u>. The region is distinctive on two counts: (i) rice occupies an unusually large percentage of the harvested acreage, 37 per

cent, as compared to the overall average of 8 per cent for the Doab; and (ii) most of the other crops are significantly absent. These characteristics justify the label of the region. Two other crops, wheat and fodder, occur moderately, while maize is significantly absent. For the most part, the region is surrounded by the rice and wheat region (IV), which suggests that rice remains an important crop in the adjoining areas, though of lesser importance in the total assemblage. An examination of Figure 13.10 reveals, however, that the two regions are different from each other in their total character.

The region is characterised by high rainfall with relatively low water requirements during the summer months, high intensity of irrigation and rich loamy soils. These factors, in combination, provide ideal physical requirements for rice cropping. The preferences of the local population for rice have already been noted (p. 168). Moreover, these areas are liable to flooding during the excessive rains, therefore restricting the choice of alternative crops. Rice can withstand these hazards and therefore provide a reasonable assurance of harvest to the farmers.

<u>II. The wheat region</u> This comprises about 5 per cent of the total occurrences, and occupies largely the southern half of Bet of Kapurthala tahsil. The other areas forming the region include parts of Garhshanker tahsil, largely concentrated around Garhshanker town. The region is characterised by low rainfall, high water requirements during the summer months, inadequate irrigation facilities and frequent flooding during the rainy season. These, in turn, do not offer much in terms of summer cropping. Wheat is, therefore, extensively grown throughout the region. The region presents an opposite picture to region I in its main characteristics, which is clearly exhibited in Figure 13.10.

Wheat shares an overwhelmingly large proportion, 56 per cent, of the harvested acreage - more than double the average figure of 27 per cent for Bist

Doab. Vegetables attain importance with over 2 per cent of the harvested acreage, but they mainly occupy areas around Garhshanker town. Fodders occur only moderately. Rice, the most important crop of region I, is most notably absent. The rest of the crops contribute very little in the total cropping assemblage of the region. The major problem is poor drainage which is causing considerable soil depletion. The high water-table in most parts adds further to the problem. The land is constantly deteriorating and consequently the yields are becoming so poor that it may no longer be economical to cultivate large tracts in Bet parts of Kapurthala. The introduction of soil and water conservation practices is highly desirable.

III. The maize and wheat region The region accounts for 6 per cent of the total occurrences and spatially is confined largely to Rakkar and Kandi (east) of Dasuya and parts of Kandi of Hoshiarpur. Elsewhere, it has a patchy and scattered distribution in Bet tracts. Maize is the leading crop, accounting for 32 per cent of the harvested acreage, double the overall figure for the Doab. Wheat occupies 45 per cent of the harvested acreage, but its relative significance is next to maize in the overall cropping structure. Pulses occur only moderately. All other crops share small, unimportant acreages. It may be reiterated that this is the only region where fodder is significantly absent. The presence of grazing facilities in non-agricultural lands (forests and other uncultivable land) and relatively lower livestock intensity may provide satisfactory explanations.

The coarse sandy soils, low water-table, dependence on rainfall, traditional outlook of the local hill people and relative isolation of the major parts of the region impose certain physical, social and economic limitations towards improving the existing farming structure. The dominance of maize and wheat clearly reveals the reliance of the region on cereals in both crop seasons.

It may be characterised as a subsistent rainfed cropping region.

IV. The rice and wheat region Of the total occurrences, 9 per cent fall in this region. Spatially, it presents a fragmentary distribution. The major concentration is in Bet and Dona of Kapurthala and southern parts of Bet of Dasuya tahsil. The other areas, forming the second concentration, include parts of Phagwara and Dhak of Nawanshahr tahsil. Though, spatially, the region occurs in close association with rice (I) and the wheat (II) regions, it exhibits much distinctive character in variable space from either of them (Fig. 13.10). In fact, it is a transitional zone between the I and II regions.

As the label suggests, rice and wheat are the two leading crops, each sharing a significant proportion of the harvested acreage in each of the crop seasons. Rice is more significant, accounting for 18 per cent of the harvested acreage. Sugarcane, cotton and fodders occur only moderately. The remaining crops are notably absent; the most important among them are inferior foodgrains - wheat/gram, gram and barley - and vegetables. The areas forming this region are relatively better-off in terms of soils, irrigation and drainage facilities, which help in achieving two crops in a year.

V. The wheat/gram and wheat region It accounts for 7 per cent of the occurrences and spatially is scattered in the drier parts of the Doab. It includes parts of Hoshiarpur, Garhshanker and central parts of Jullundur. For the most part, lack of irrigation facilities, susceptibility of these areas to floods, caused by numerous hill torrents, and sloping sandy soils impose physical limitations on *kharif* cropping and consequently most of the land is left for relatively more secure winter crops. Wheat/gram is the leading crop of the region, accounting for 27 per cent of the harvested acreage. Wheat comprises 29 per cent of the harvested acreage and is the second leading crop of the region.

Gram and barley occur only moderately. The summer crops are conspicuously unimportant. Rice is most notably absent.

VI. The wheat/gram, maize and fodder region In terms of frequency of occurrences, the region is the third largest and accounts for over 12 per cent of the occurrences. Spatially, it is confined largely to Hoshiarpur district. Elsewhere, it occurs in a few isolated patches in Dona Charhda of Jullundur. An examination of Table 13.3 clearly reveals the dominance of crops which are raised largely under rainfed conditions. Wheat/gram gains the highest status, accounting for 35 per cent of the harvested acreage. An interesting feature of the region is the very low acreage under wheat as a pure stand. This circumstance reflects the utility of wheat/gram mixed crop - a crop which acts as an insurance against lack or excess of moisture in these areas of uncertain environmental conditions. Maize and fodder totals 18 and 17 per cent of the harvested acreage respectively. The other important crops of the region are sugarcane, pulses and grams.

In terms of agricultural development, the region is relatively poor. The cropping is mostly carried out under rainfed conditions. Soil erosion on the hill slopes, and sand spread through choes in the lower parts are serious handicaps to farming. The highly porous nature of soils pose further problems to any extensive irrigation network. In parts of Sirwal tract of Hoshiarpur tahsil and some other favourable parts, irrigation through tube-wells is breaking into the traditional farming practices.

VII. The wheat, fodder and maize region This is the largest, the most compact and the most important of all the regions. It accounts for one fourth of the total occurrences and includes most of Jullundur district, parts of Phagwara and Hoshiarpur tahsil. Elsewhere, it occurs in isolated patches scattered in Garhshanker and Kapurthala tahsils. The region offers excellent conditions in terms of physical and human resources. Due to a high intensity of irrigation, multiple cropping is practised widely. Jullundur district is the second most progressive district in Punjab, in the adoption of new farming innovations. It is this part of the Doab which presents the most stable farming structure. Wheat, fodder and sugarcane are grown on commercial scales. The rail/road net work is excellent.

Wheat is the leading crop accounting for one third of the harvested acreage. Yields are high and most of the crop is of high-yielding varieties. Fodders account for over 20 per cent while maize 17 per cent of the harvested acreage. Sugarcane attains the highest percentage in the region. Cotton too is a significant crop. The region is one of commercial cropping.

VIII. The diversified region It is the second largest and widely scattered region, accounting for 17 per cent of the total occurrences. It is a transitional region between the rainfed cropping region (VI) and the irrigated region (VII). The region is characterised by the presence of most of the crops. The most significant of them all, however, is maize which alone accounts for about one fourth of the harvested acreage. Among cereals, sugarcane totals 6 per cent, fodders 19 per cent and vegetables 3 per cent of the harvested acreage. Cotton and pulses occur moderately. Only two crops, oilseeds and rice are notably absent.

Spatially, the occurrence is largely confined to the drier eastern parts, but some isolated parts of Jullundur and Kapurthala are also included. The region is a transitional zone between the subsistent cropping of the east and west and the commercial cropping of the central Doab. With better agro-irrigation facilities in the near future, this region may eventually become merged into either of them.

IX. The oilseeds region The region comprises 5 per cent of the total occurrences and is highly significant in terms of economics of Bist Doab. It is a compact region, comprising Dona of Nakodar and Kapurthala and Dona Lehnda of Jullundur tahsil. Groundnuts are the single most important oilseeds grown. The region is unique on two scores: (i) oilseeds account for an unusually high percentage of the total cropping (41 per cent), though the average figure for the Doab is under 4 per cent; and (ii) most of the other crops are significantly absent (Table 13.3). This surely justifies the label of the region. Among other crops, cotton is significant and totals 3 per cent of the harvested acreage. All other crops occur at much below the average levels.

The high prices during the last decade, coupled with the shortage of vegetable oils have created a large demand for oilseeds. Considering the shortage of oilseeds on a national scale, and the consequent need for encouraging the growing of oilseeds, these areas will remain very important. Further improvements in the cultivation practices, use of better seeds and better market facilities can go a long way in increasing the production of oilseeds in these parts. It may, however, be suggested that installation of the processing mills in this region is highly desirable.

X. The vegetable region Though the region accounts for less than one per cent of the occurrences, it is very significant as it represents a new trend in cropping. It is largely localised around the major urban centres, Jullundur and Hoshiarpur. The importance of vegetables and the factors leading to their localised occurrence has already been noted (p. 243). Vegetables total 29 per cent of the harvested acreage, a figure fifteen times higher than the average for Bist Doab as a whole. Fodder is the second most important crop of the region, accounting for 26 per cent of the harvested acreage. All other crops remain unimportant as they occur at much below the average figures. An interesting point which emerges here is the conspicuously low acreage under cereals. Maize occurs moderately and this may be due to its multiple uses.

With the increasing urban population, the demand for vegetables is bound to increase. Also with improvements in standards of living, the eating habits of the people are undergoing a change. Consequently, vegetable growing may well spread more intensively around these urban markets.

PART V

THE CHANGING AGRICULTURAL ENVIRONMENT

Prior to Independence in 1947, the Indian Punjab, as the rest of India, was largely a region of self-sustained villages in which traditional agriculture, based on centuries of experience, was more a way of life than a business. Most essentials were home produced and outside needs were limited. From the beginning of the last quarter of the nineteenth century, Punjab, especially Bist Doab, also suffered from intense pressure of population upon available resources and there was migration of people out from these parts (p. 96).

Because of the continuing pressure of population, the region had to maintain a high level of cultivation. About three quarters of the geographical area of the Doab was under plough, industry was almost non-existent, and urbanisation limited and static. Non-agricultural land occupied only a small proportion of the area, 12 per cent, and the prevalence of traditional and primitive techniques of farming accounted for a similar proportion of cultivable waste. Of the total cultivated area, four fifths was sown every year, leaving one fifth as fallow. The high incidence of fallow is largely a reflection of rain dependent farming. Irrigated land comprised two fifths of the cropped area, but by methods which were largely inefficient and inadequate and designed simply as supplementary provision. Consequently, only a small proportion (some 13 per cent) of the net sown area was cropped more than once.

The typical response to increasing demands was to expand the cultivated area rather than to strive for increased productivity. In the traditional agricultural pattern both seasonal and perennial crops played a part, with diversification emphasized rather than specialisation of a limited range of crops. Intercropping was also more characteristic than cropping in pure stands, cultivation by wooden plough was almost universal and the cropping practices customary. Crop yields were low. Fertility was largely maintained by keeping the land as fallow, by green manuring, and, within limits, by using cow dung and composite manures. In general, the peasant approached agricultural production with the aim of minimising risks rather than ensuring maximisation of production or profits.

Transport was inadequate and inefficient and internally mainly by cart and donkeys. Marketing facilities were limited and storage facilities almost non-existent, while the use of mechanical power in farming operations was almost unknown. Holdings were fragmented, and the system of land tenure unfavourable to increasing agricultural production (p. 6). The role of government had largely been restricted to passing legislation, albeit ineffective, to enlarge the rights of tenants. Trade terms, too, were unfavourable, and the 'middle-man' made more profits than the cultivator or landlord. Research in farm operation was encouraged in a modest way but the results were confined within the official files. In effect, there was no qualitative shift in overall agricultural patterns in the direction of genuine modernisation. As a result, Punjab's agriculture continued to function as the backward sector in the dual economy.

Shortly after Independence, the Government of India decided that drastic economic changes were essential to survival. A new chapter of planned economic development began with the launching of the first of many Five-Year

Plans in 1951. This was succeeded by various other Plans and Programmes which were geared towards increasing agricultural production (p.360). The period between 1950 and 1970 saw profound changes in the agricultural scene of Punjab. These changes are largely reflected both in expansion and intensification of cropping. Contributing factors have included technological advances, such as irrigation, soil and water conservation, adoption of HYV, use of chemical fertilizers and pesticides, improvement in means of transportation, marketing and storage facilities, price incentives and, above all, the changes in mental attitudes of the farmers, the policy makers, the researchers and the politicians. In combination, these have converted Punjab from a deficit State in 1947 into one which has not only achieved self-sufficiency, but also is well endowed with the potential for growing substantial surpluses of foodgrains for the nation. Such a development is in response not only to these technological advances but also to important modifications in both national and international economies. The total visible, which can be mapped, and invisible, which cannot be mapped, imprint of changing rural landscape form the substance of this part.

The changes in various components of landuse and cropping and other aspects related with agricultural development are assessed in relative terms. The use of absolute terms has been limited and these are largely used to emphasize a particular aspect of change. This is obvious in the text. The terms used in this part are defined specifically and are listed in the Appendix I.

CHAPTER 14

CHANGES IN LANDUSE AND LAND-USE PATTERNS

The radical changes which took place in the agriculture of Bist Doab, or for that matter in Punjab, during the period under review had a marked impact on the various landuse elements of the region. The aim of this chapter is to record and analyse the changes in various forms of landuse, unravelling the spatial differentiation in respect of the individual elements, to indicate trends by analysing the data for the period 1951-68, and, finally, to delineate landuse change regions.

CHANGES IN LANDUSE

The primary elements considered were agricultural land, potential agricultural land and non-agricultural land and changes were assessed in their extent and pattern. Agricultural land increased slightly from 1,625,000 acres in 1951-52, to 1,663,000 acres in 1968-69, an increase of 2.3 per cent as against 4 per cent for Punjab as a whole. A significant expansion occurred in the category of non-agricultural land (forests included) which increased in acreage from 281,000 acres in 1951-52 to 533,700 in 1968-69, an increase of 89 per cent, the corresponding figure for Punjab being 26 per cent. Together these changes reduced the acreage of potential agricultural land by about 87 per cent, from 241,000 to 30,400 acres. Though these changes are substantial, the pattern produced by them is more complex than the aggregate statistics can reveal. Although an increase in one type of landuse must necessarily produce a decrease in another, all possible combinations of landuse changes involving the various elements were observed in varying degrees.

The primary explanation for the changes in landuse lies in the population growth and urbanisation, the main instruments of change. Other important contributory factors include expansion in irrigation, improvements in road transport, increasing government intervention since 1951, and a common desire of the Punjabi farmer for a higher standard of living. A major force inducing change was the new settlers who migrated to Indian Punjab after the Partition of the country in 1947. Provisionally they were given 10 acres of land per family, but later were allotted land in proportion to their land holdings in Pakistan. This helped in two ways, firstly, in the process of land allottment, most of the farms were consolidated (some partially and some fully); and secondly, since these farmers had experience of reclaiming new lands and were more progressive in their outlook than their local counterparts, they strived hard to bring every available parcel of land under plough to meet the challenge of deteriorating food supplies.

Changes in extent

The changes in the extent of cultivation (Fig. 14.1) reveal both gains and losses, but while the gains come mainly from the reclamation of potential agricultural land and partially from the clearing of forests, the losses are largely the result of urban encroachments and other development projects on agricultural land as well as the abandonment of 'degraded land'. To understand the precise nature, extent and direction of these changes, it is essential that consideration be given to the changes in non-agricultural land and potential agricultural land (Figs 14.2 and 14.3) from which three broad categories emerge.

(i) Expansion of agricultural land, due to the continued pressure of population upon available agricultural land resource, was very limited. This was accentuated by the loss of agricultural land, generally of above-average quality, through the implementation of development plans. As a result, expansion in agricultural land was minor (less than 10 per cent) and very scattered and patchy in distribution. Some areas around urban centres have gained over 10 per cent. On the whole, expansion in agricultural land occurred in three ways: (i) reclamation of waste lands (potential agricultural land); (ii) conversion of non-agricultural land, especially forests, to agricultural uses; and (iii) from the interaction of both (i) and (ii).

The reclamation of potential agricultural land (see the Venn diagram, Fig. 14.4) predominates although non-agricultural land has contributed to a lesser degree. However, two interesting corollaries (shaded) emerge from Figure 14.4. First, a considerable proportion of the occurrences show a decline in potential agricultural land and increases in both non-agricultural and agricultural land. This may be explained in terms of the magnitude of the loss of potential agricultural land. Secondly, a small proportion of the occurrences show a decline in non-agricultural land but increases in both potential as well as agricultural land. This is a rare instance but is very meaningful. Since non-agricultural land nearly always goes directly into agricultural land, this represents the reversion of agricultural land to potential agricultural land - an element exhibiting degradation of agricultural land. This reversal is highly detrimental to agricultural development and the reasons for decline deserve study for remedial purposes, if no other.

In view of the history of the region, any expansion in agricultural land must look towards potentially cultivable lands. The increasing population and the general food shortages during the 50's imposed heavy strains on the agricultural land, and most of the potentially cultivable land was converted to agricultural land. The need to bring more land under cultivation was so great that even the forests were cleared and the land brought under cultivation. Subsequently, the village common lands including graveyards and small village ponds were also reclaimed. This represents an intensive effort and considerable investment both by the farmers and the government. Any future expansion in the extent of cultivation must therefore be marginal and efforts to expand production must look towards (i) increasing the intensity of cultivation and (ii) increasing the intensity of cropping.

(ii) Losses of agricultural land have been small in percentage terms but widespread in their areal coverage, and largely comprise degraded lands and areas around major industrial towns. Two explanations can be offered for these losses: (i) development projects and (ii) land abandonment.

During the post-Independence period, the region, as the rest of Punjab, has experienced a marked transformation in terms of general development. This largely includes rapid urban expansion, development of industries, the construction of a road and rail network, construction of canals, school buildings and play-grounds, army installations, airfields, and other public amenities. For example, a journey from Ludhiana to Amritsar, on Grand Trunk Road, provides evidence of reconstruction of small scale agricultural and non-agricultural industries on both sides of the road. The major industrial nuclei of the region are Jullundur, Phagwara, Phillaur and Kapurthala.

Both urban and industrial expansion in the region as elsewhere in

Punjab, has however, been uncontrolled and haphazard. Indeed, a major drawback of planning up to the early sixties has been the lack of effective legislation which could prevent this haphazard growth. Consequently, agricultural lands have been converted to non-agricultural uses irrespective of their agricultural quality or their value to the nation. At the same time it led to high prices for agricultural land as the industrialists could offer 3-4 times more cash than the prevailing rates for agricultural land.

As a result of deforestation, soil erosion and subsequent waterlogging also resulted in the degradation of some agricultural land. The situation deteriorated further as the construction of canals and roads hampered the natural flow of rain water. In the low-lying areas of the Bets, waterlogging is conspicuous. Likewise, the sand-spread in the choe-infested parts in the east has had an impact. The result has been the abandonment of much agricultural land.

From the Venn diagram (Fig. 14.5), it is clear that the losses have been largely through the conversion of agricultural land to non-agricultural uses, and are spread over most of the central parts of the Doab. This also includes a proportion of potential agricultural land which has gone to non-agricultural land. Though these changes were largely inevitable, they are of major significance since they are largely irreversible. In detail, three situations emerge. First, in about 6 per cent of the occurrences, the conversion of agricultural land to potential agricultural land represents partial abandonment of the agricultural land due to soil erosion and sand-spreads in the eastern parts of the Doab. Second, a similar proportion represents those parts where both potential and non-agricultural land have gained at the cost of agricultural land. In these parts, the losses have been very high, over 10 per cent of the total area (Fig. 14.1). Thirdly, and more importantly, are the areas where despite the decrease in non-agricultural land, agricultural land has also suffered heavy losses, largely over 10 per cent of the total area, at the confluence of Sutlej and Beas rivers in the south-west and parts of Rakkar of Dasuya and Hoshiarpur.

On the whole these areas represent the crisis areas and need the serious attention of the farmer, the planner and the government. It may, however, be pointed out that the deterioration of these lands is not due to lack of effort or initiative on the part of the farmers. Rather, these losses have occurred for reasons beyond the control of the individual farmer. They demand elaborate and expensive development plans to control the flow of the rivers and choes.

(iii) Stable agricultural land, occurs over large areas where change has been negligible and, in few cases, areas where the change in one element of landuse has been compensated by the other without having altered the proportion of agricultural land. This category accounts for over one third of the occurrences (Fig. 14.6) and is confined to rainfed areas in the east as well as central parts of diversified farming. A small anomaly (shaded) is presented by areas where potential agricultural land has decreased without altering the proportion of both non-agricultural and agricultural land. Two explanations can be offered for this. First, these areas may represent marginal cases as the decreases account for less than 2 per cent of the total area. Second, it may be due to the boundary adjustments which occurred during the consolidation processes.

Changes in intensity of cultivation

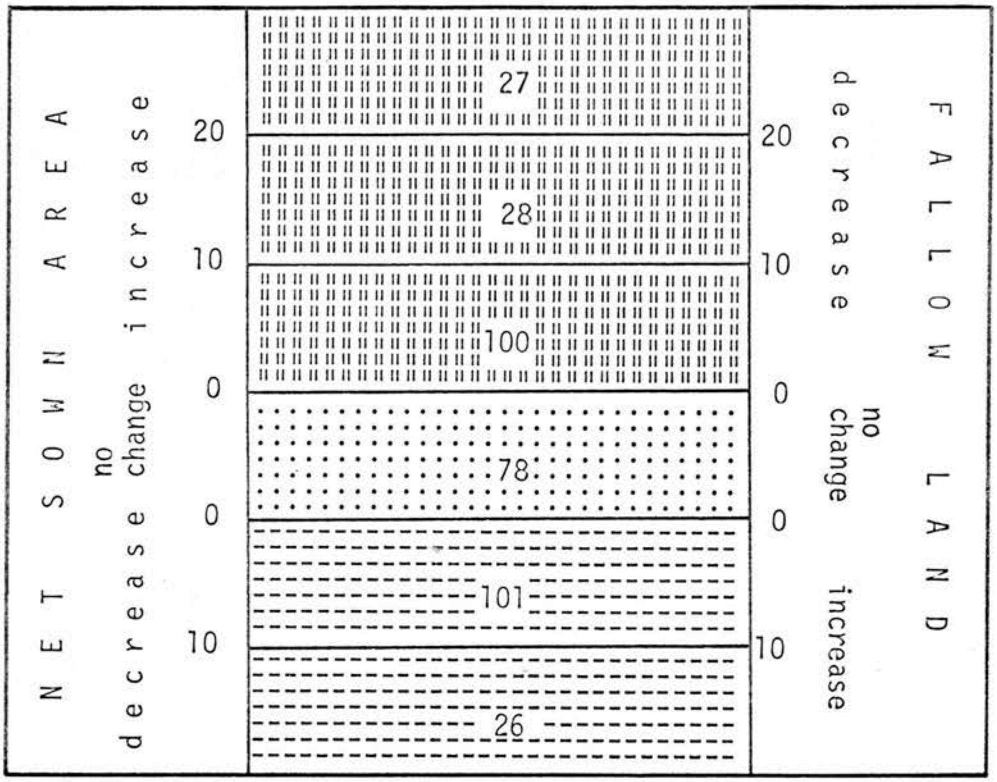
In the preceding discussion, it was observed that the expansion in the extent of cultivation has been very modest. Under the compelling needs for increasing food production, the other immediate choice was, of course, to utilize the available agricultural land to its fullest possible extent. This obviously meant enhancing the intensity of cultivation through expansion in the proportion of net sown area with a corresponding contraction in fallow land. The improvement in irrigation facilities and the use of chemical fertilizers helped a great deal in achieving a higher intensity of cultivation in most of the area. The use of intensity of cultivation as a factor in the changes in landuse is of particular importance as it relates to the actual activity of farming and reflects the effectiveness and efficiency with which the land is being utilized.

On the whole, the net sown area in Bist Doab has shown appreciable increases. In 1951-52, the net sown area was 1,285,500 which expanded to 1,593,800 acres in 1968-69, an increase of 24 per cent (the corresponding figure for Punjab was only 11 per cent). Conversely, the fallow land declined from 339,900 acres in 1951-52 to 69,200 acres in 1968-69, a decrease of 80 per cent as against 53 per cent for Punjab. But these overall changes do not portray the true spatial picture of the Doab. Like the extent, the changes in intensity of cultivation, include both gains and losses.

The spatial distribution of changes in net sown area and fallow lands are given in Figures 14.7 and 14.8 respectively, and may be grouped into areas of increasing, decreasing, and stable intensity of cultivation (Table 14.1). It should be noted that the changes in intensity of cultivation follow a similar pattern as the changes in extent of cultivation (cf. Figures 14.1 and 14.7) and largely for similar reasons.

<u>Increasing intensity</u>, that is, gains in net sown area and losses in fallow, account for about two fifths of the occurrences. Largely, these gains are less than 10 per cent of the total cropland and are spread throughout the

TABLE 14.1 CHANGES IN INTENSITY OF CULTIVATION IN BIST DOAB, 1951-56/1961-66



Figures in the cells denote frequencies

Total number of occurrences 360

127 Category of increasing intensity

155 Category of stable intensity

78 Category of decreasing intensity

Doab. In areas of commercial farming and around urban centres, however, increases in intensity are maximum. Elsewhere the gains range between 10-20 per cent of the cropland and correspond largely to areas of expansion in agricultural land. Most of the area has already reached saturation points with the exception of Dona of Kapurthala and Nakodar, where more irrigation facilities would provide some scope for expansion. Elsewhere the choice is very limited and environmental difficulties hamper any appreciable development.

Decreasing intensity, where the proportion of net sown area has declined and the proportion of fallow land has increased, accounts for over one third of the occurrences. The distribution is very scattered and confined to the rainfed parts of the Doab or areas with minimal irrigation facilities and the waterlogged areas in the Bet tracts. Consequent to the losses in agricultural land around urban centres, the losses in net sown area were almost inevitable. The losses in net sown area in the rainfed parts can be explained in terms of environmental hazards. The waterlogged areas, however, reflect the deterioration of agricultural environment and illustrate a continuing trend in the degradation of land.

Stable intensity of cultivation accounts for one fifth of the occurrences and is confined to areas where both canal and well/tube-well irrigation facilities are available. These parts are largely areas of diversified farming and in terms of availability of agricultural land, they have almost reached their saturation levels. The only method of expanding production here is to increase the intensity of cropping. This has been observed.

In summary, over most of the Doab, the physical expansion of agricultural land has already reached its maximum level. The areas with

TABLE 14.2 PERCENTAGE CHANGES (MEAN VALUES) IN LANDUSE IN VARIOUS LAND-USE CHANGE REGIONS: 1951-56/1961-66

Region	Frequency of occurrence	Agricultural land	Non-agricultural land	Potential agricultural land	Net sown area	Fallow land
I. Region of intensive cultivation	87 (24.17)	0.24	0.11	1.58	17.23	-31.72
II. Region of expanding cultivation	27 (7.50)	11.76	1.67	-13.44	- 0.20	0.20
III. Region of stable land-use	197 (54.72)	- 0.52	0.80	- 0.28	- 0.41	0.41
IV. Region of declining cultivation	49 (13.61)	- 4.94	1.20	4.75	-13.32	7.20
Overall	360 (100.00)	0.10	0.61	- 0.70	2.11	- 2.90

Figures in parenthesis indicate percentages possible expansion potentials present environmental difficulties which must be recognised and overcome before any future expansion is possible. Under these circumstances, an increase in food production must come from the expansion in intensity of cropping.

CHANGES IN LAND-USE PATTERNS

By land-use pattern is meant the proportion of area under different landuses at a point in time. A change in land-use pattern implies an increase or decrease in the proportion of area under different land-uses at a point in two or more time periods. These changes provide a synthesis of various landuse changes and are better expressed in the land-use change regions which form the substance of this section.

Land-use change regions

The land-use change regions were established by applying a hierarchical grouping algorithm, the details of which have already been discussed (p. 250). After a close examination of the dendrogram produced by the grouping algorithm, four groups were finally recognised. These represent the most distinctive regions: (i) of intensive cultivation; (ii) of expanding cultivation; (iii) of stable cultivation; and (iv) of declining cultivation. The significance of these regions in the present study is two-fold: (i) they provide a synthesis of the changes of the landuse elements discussed in the preceding pages; and (ii) they can form the broad basis for future land-use planning of the Doab.

The spatial pattern of these regions is presented in Figure 14.9 and summary statistics are given in Table 14.2. To examine the relationship between the regions, a multidimensional scaling (MDS) procedure was used and is exhibited in Figure 14.10. It is clear that these regions are distinctive in their essential characteristics. The spatial distribution, however, reveals a fragmentary spatial pattern. Yet the patterns produced by these regions reflect the general trends of the change patterns observed earlier.

The region of intensive cultivation (I) accounts for one fourth of the occurrences, and is largely concentrated in the south-west. Elsewhere, it has a scattered and patchy distribution. Although there is a substantial increase in net sown area, 17 per cent, with the consequent decline of about 32 per cent of the cultivated area in the fallow, the extent of cultivation remains virtually stable. Potential agricultural land has only marginal gains.

The region of expanding cultivation (II) comprises only 8 per cent of the cases. It has a scattered distribution but occurs in close conjunction with the region of intense cultivation. Despite substantial gains in the extent of cultivation (12 per cent), the intensity has practically remained unchanged. Non-agricultural land has increased by about 2 per cent.

Although regions I and II reveal a distinctive change in their basic land-use elements, nonetheless, they indicate essentially the expansion of agriculture. The extension of irrigation in both these regions has contributed to a greater area being brought under cultivation as well as enhancing the intensity of cultivation, though the pressure of population cannot be discredited. From the comparison of Figure 8.4 and 14.1, it may be concluded, however, that any future expansion in the extent of cultivation will be marginal. As such the region of expanding cultivation will eventually merge with region I. Moreover, the scope of further intensification of cultivation is also limited (cf. Figures 8.5 and 14.7) and after reaching their stabilization, both regions (I and II) will merge with region III. It must not be forgotten, however, that the problems of region IV, may spread to parts of the regions I and II.

The region of stable land-use is the largest and most compact of all. It comprises 55 per cent of the cases and occurs largely in different situations: (i) irrigated central and northern parts of the Doab - Phillaur, Nawanshahr, Jullundur, Sirwal tract of Hoshiarpur and Garhshanker, and Sirwal, Maira and Bet of Dasuya; and (ii) rainfed parts in the east, parts of Kandi and Rakkar of Hoshiarpur district. These locations demand separate explanations.

In the irrigated parts, the land has remained stable partly because the scope for any expansion was marginal and partly because of the fact that the limited gains and losses in various landuses have balanced each other out. Both extent and intensity of cultivation have almost reached saturation level (over 80 per cent of the total area is under cultivation and, for large parts, over 95 per cent of the agricultural land is sown every year). These parts are also on high levels of general development, especially of agricultural infrastructure. They will remain stable and the future strategy for these areas lies largely in intensive cropping by way of double or even relay cropping.

The rainfed parts, on the other hand, have remained stable on account of environmental difficulties, which hamper rural reconstruction in many ways. Irrigation facilities, through subsoil water or surface water, are difficult, if not impossible, to provide (Chapter 5). These parts also lack urban development and rail-road network, and local population lacks the initiative and skills found elsewhere in Punjab. It seems probable that these areas will continue in their present way for some time to come.

The region of declining cultivation is the smallest and most scattered of the regions. It has suffered serious losses both in extent and intensity of cultivation. Still worse is the fact that losses have gone to potential agricultural land and fallow - an element exhibiting degradation of agricultural land observed earlier. Non-agricultural land has modest gains. It accounts for 14 per cent of the occurrences and occurs largely in two situations: (i) flood-affected and waterlogged parts of the Bet tracts and some areas around East and West Beins; and (ii) areas faced with the problems of soil erosion and sand-spreads, especially in Kandi of Hoshiarpur and Dasuya. A loss of agricultural land around major urban centres is also evidenced, for reasons explained earlier. This region is a problem region and reflects the general deterioration of agricultural land resource.

TRENDS

Figure 14.11 indicates the overall trends in both cultivated area (reflecting extent of cultivation) and net sown area (reflecting intensity of cultivation) in Bist Doab for 1951-68. The regression lines show a steady increase in both, though the trend is more marked in the case of net sown area. Yet, these trends mask detailed variations and do not depict the regional contrasts observed earlier. Three different trends have been operative in Bist Doab. Most of the central parts of the Doab have maintained a stable pattern of land-use. The Bet and Kandi tracts have persistently shown decline of cultivation. Elsewhere, the trend has been towards expansion in either the extent or the intensity of cultivation. It seems that the future trends will be largely towards stabilization of land-use, while the degraded parts may deteriorate further, if proper measures are not taken in time. These trends are by no means confined to Bist Doab or Punjab, but are the characteristics of the whole of northern India which provides a major food resource of the country. The obvious implication of these trends would be that the future food requirements of fast increasing population must come from increases in intensity of cropping, failing which the results could be gloomy indeed.

CONCLUSIONS

During the three Five-Year Plans period, some major shifts in the land-use of the Doab have been recognised, which can be attributed partly to the efforts and initiatives of the farmers and partly to the incentives provided by the planning processes operative in Punjab. These shifts are reflected in the changes in various land-use elements. The expansion in the extent of cultivation has been modest and has largely come from the reclamation of potentially cultivable lands. The losses, on the other hand, have been largely through the conversion of agricultural land to non-agricultural uses such as urban expansion and development projects, and partly as a result of the abandonment of 'degraded lands'. Since the scope for the expansion in extent of cultivation was limited, the gains largely resulted from changes in the intensity of cultivation. Following the substantial expansion in irrigation, gains in intensity have been high. By analysing these changes and examining the emerging patterns of both the extent and the intensity of cultivation, it was possible to establish that most of the Doab now exhibits a relatively stable pattern of agricultural land-use.

Through an analysis of the interrelationships among the changes in different land-uses involving both extent and intensity, it was possible to delineate regions showing similar patterns of changes. Four such regions were recognised. It is interesting to note, however, that regions I and II, both reflect essentially the expansion of agriculture, although the second is characterised by increases in extent while the first, and larger, represents increases in intensity. Region III, which accounts for over half the observations exhibits stable cultivation, while region IV represents a declining cultivation. It was noted that the areas of expanding cultivation are approaching stability in their land-use pattern. When these results are compared with the trends based on aggregate statistics the value of such detailed studies is immediately apparent. Although the aggregate trend shows an increase in extent the regional approach reveals that the majority of areas are stable and that there are areas suffering decline, factors which throw a quite different light upon land-use changes.

The implications of these results is that new development policies must be formulated. The planning policies during the three Five-Year Plans period, have been very broad-based, largely geared towards extensions of cultivated area as an important means of increasing agricultural production. Mostly they were based on aggregate statistics and inhibited by the setting of overall targets. Small-scale initial planning was virtually eliminated, and very little, if any, of the local knowledge was utilized, the Punjabi farmer's rich fund of empirical knowledge being largely ignored. The study has revealed the need of a change in the nature and direction of planning. The most obvious feature to emerge is that policies designed to increase production must now focus their attention upon increasing intensity since the scope for increases in extent is virtually exhausted. Most importantly it is suggested that future policies must be formulated on a regional basis. These must be based upon more detailed statistics which can reveal a much more accurate picture as this work demonstrates. In areas of stabilization, conservation of the agricultural land resource, is as important as, if not more than, increasing production. The crises areas, on the other hand, where cultivation is declining, demand immediate and detailed investigation of the specific problems responsible for the decline and the provision of the resources necessary to rectify the situation. A by-product of such policies would be a greater understanding of potential problems for the stable areas which would produce better policies of land conservation. An additional concern is that the planning of development projects and urban expansion must attempt to avoid the consumption of productive agricultural land in so far as is possible. In general the problems posed to Bist Doab by the degradation of agricultural land (although the problem exists throughout Punjab and even through the whole of India) is critical and the primary concern of future policy must be to prevent further deterioration as well as to restore the use of already degraded lands, for these are the most valuable national resource.

CHAPTER 15

CHANGES IN CROPS AND CROP PATTERNS

Agricultural change in the region has involved certain, limited land-use modifications. These modifications represent an expression of equilibrium between the exogenous and endogenous forces influencing farming at different times. In response to these forces, farmers have continually altered their techniques of farming as well as the proportion of land under different crops. The aggregate results of these individual actions are reflected in the changes in the various crops and their interactions, in the intensity of cropping, and thereby in the delineation of crop-pattern change regions.

Changes in the intensity of cropping

The rapid expansion of irrigation facilities, the introduction of early-maturing varieties of crops, the use of chemical fertilizers, and above all, the need for growing more food necessitated by rapid increases in the national population, equipped the farmers to expand cropping by producing more than one crop in an agricultural year. Equally important, however, has been the consolidation of holdings, which was completed in Punjab in 1968-69. It has been estimated that agricultural production increases by about 25 per cent, without change in techniques, in a consolidated farm (Randhawa, 1974: 43). Consequent to these developments, the area sown more than once has increased by over 200 per cent, from 171,600 acres in 1951-52 to 521,400 acres in 1968-69, compared, for example, with the 115 per cent increase for the Punjab as a whole. The cropped area also increased from 1,457,000 acres to 2,115,200 acres during the same period, showing an increase of over 45 per cent as against 27 per cent for the State. This resulted in an increase in the intensity of cropping for the Doab from 113 in 1951-52 to 133 in 1968-69. The corresponding figures for Punjab were 118 and 134 per cent respectively.

The spatial distribution of the changes in intensity of cropping (Fig. 15.1), indicate both gains and losses, but, while the gains have been considerable, the losses have been very small. Increasing intensity of cropping is by far the largest zone, comprising most of the Doab and accounting for 78 per cent of the observations. These gains, for the large part, have been less than 50 per cent of the net sown area. Yet, in some more favourable parts, the gains have been high - ranging between 50 and 100 per cent or even more of the net sown area. These high gains, though scattered and patchy in their distribution, largely reflect rural-urban interactions in farming. They occur around and within the effective limits of the urban centres. In the case studies (Chapter 12), these rural-urban interactions and the causes thereof, have already been discussed.

Such gains can be attributed to factors which include new material inputs (water, inorganic fertilizers, pesticides), new outputs (new crops, improved varieties, early-maturing varieties), new implements and power sources (steel implements, powered implements, and diesel and electric engines as sources of power) and new cultural practices (multiple and relay cropping). Yet, irrigation remains the most important single factor and provides the farmers with the base for the adoption of other innovations. Moreover, the '...mechanisation of irrigation via pump-sets cuts down the time required for irrigation by as much as 75 per cent, allows the cropping intensity to rise, and brings about considerable increases in yields' (Byres, 1972).

Decreasing intensity of cropping (16 per cent of the occurrences) is confined to few areas. Largely the losses are below 25 per cent of the net sown area and come partly from flood-affected and areas of sand-spread, where agricultural land is facing decline , and partly from areas around urban centres, where impending urban expansion is affecting agricultural developments considerably. Only 4 per cent of the cases exhibit losses of over 25 per cent which represent largely degraded areas in the flood-affected and waterlogged parts of the Doab. Elsewhere the decline in intensity may be assigned to some rainfed areas where agriculture, by any standard, has been marginal.

Stable intensity of cropping has limited distribution (7 per cent of the occurrences) largely concentrated in Bets of Kapurthala, Nakodar and Garhshanker, with a few isolated patches elsewhere. In Chapter 14, both stable extent and intensity of cultivation accounted for a much higher proportion of the occurrences, 35 and 22 per cent respectively. This suggests that though large areas have attained stabilization in the expansion of cultivation, improvements in the form of increases in intensity of cropping have been possible and in fact have taken place. It is probably this aspect which makes the study of intensity of cropping much more meaningful.

Together, the zones of stable and decreasing intensity of cropping are characterised by a region of declining cultivation for reasons explained elsewhere (p.276), but these areas present a setback to the expanding agricultural economy of the region. However, more insight into the problem can be obtained through looking at the changes in individual crops and their interactions.

Changes in cropping

The three Five-Year Plans saw profound changes, both qualitative and quantitative, in the cropping assemblage of the Doab as in the rest of Punjab. During the initial phases of agricultural development, a general expansion in irrigation accompanied by self-controlled, assured supplies of water, and later followed by the introduction of new inputs, especially new varieties of seeds and inorganic fertilizers, coupled with improved farming techniques, fundamentally altered the resource structure of agriculture for a considerable area of cropland in the study area. Perennial irrigation, wherever available, sharply reduced agricultural dependence on rainfall and provided to agriculture a degree of dependability and security. Consequently, crop failure was substantially reduced or, perhaps more accurately, was confined to those areas which remained outside the command of irrigation systems. As a result, a new set of agricultural possibilities emerged. Certainly, some striking shifts in the agriculture of the perennially irrigated areas to more water consumptive crops - and not incidentally, high-yielding and more profitable crops - were expected to follow.

Overall, three major developments can be recognised: (i) expansion in the cropped area; (ii) increases in crop productivity; and (iii) shifts in cropping pattern. As a result of the interactions of the three, agricultural production has increased substantially. Foodgrain production, for example, has increased by 150 per cent in the Doab, from 397,000 tons in 1951-52 to 988,000 tons in 1968-69 (the corresponding figure for Punjab, however, was over 200 per cent). But these increases have been entirely in food cereals as the food pulses have declined in both acreage and production. In the Doab, the decreases in pulses were of the order of 71 per cent in acreage and 47 per cent in production during the period under review (compare Punjab with 54 and 45 per cent respectively). Cash crops, too, have shown appreciable increases. The acreage under cash crops increased by 70 per cent and production by 47 per cent, but in the case of Punjab these were, 82 per cent and 158 per cent.

The general trends in acreage, yield and production of important crops in the Doab (Table 15.1) reveal that the shifts in cropping have been in two directions: (i) from low-yielding-drought-resistant crops - Jowar, gram, cotton (desi) and pulses - to high-yielding water and fertilizers responsive crops - wheat, maize, rice and cotton (American); and (ii) the emergence of new crops such as potatoes, American cotton and groundnuts.

In terms of acreage, all major crops have gained considerably, while gram, pulses and cotton (desi) have declined. Gram, for example, was a major crop in the beginning of the period and showed appreciable increases in the first decade (1951-61), but with the emergence of seed-fertilizer-irrigation technology, the crop has been increasingly confined to those areas where such technology has not, or cannot, penetrate. Another interesting corollary is presented by American cotton and desi cotton. Desi cotton has shown a persistent decline while American cotton showed persistent increases in acreage throughout the period under review.

In terms of productivity and production, a major breakthrough has been in the main cereal crops. Wheat and rice have gained considerably, while maize, although it has more than doubled in both acreage and production, has yet to see a real breakthrough in productivity. Among the cash crops, groundnuts have exhibited record increases in both acreage and production for reasons explained elsewhere (p. 291).

Wheat The most remarkable feature of post-Independence changes in the cropping assemblage of Punjab has centred around the success story of wheat-production technology. The Green Revolution in Punjab or for that matter in northern India has largely been a 'wheat revolution'. Within the span of two decades (1951-71), Punjab has doubled its acreage, trebled its yield, and increased the production of wheat by about 5 times. The performance of Bist Doab, though small in comparison with Punjab as a whole has, nonetheless, been commendable. Here, wheat acreage has increased by 50 per cent, while the yield and production have almost doubled during 1951-52 to 1968-69 (Table 15.1). These contrasts can be explained largely in terms of environmental limitations. For instance, in most of the eastern parts of the Doab wheat is raised as a rainfed crop which gives very low yields. In some of the western and central parts - Bet tracts - rice has emerged as an important crop (Chapter 10). This has lowered the wheat acreage in these parts considerably. The combination of these two situations depresses the overall performance levels of Bist Doab in wheat. It should be noted that while Jullundur and Kapurthala are the high-yielding wheat districts, Hoshiarpur has the lowest yields of wheat in the State.

Key factors in the accomplishment of 'wheat revolution' have again been the expansion of irrigation, which permitted an increase in multiple cropping and a substitution of wheat for other rabi foodgrains, improved cultural practices, which included the introduction of seed-cum-fertilizers drills, use of power wheat harvesters, threshers, and tractors, the use of inorganic fertilizers, the rapid adoption of high-yielding wheat varieties, and minimum guaranteed wheat procurement prices since 1966. Finally, and perhaps more importantly, the response of Punjabi farmers was favourable to

TABLE 15.1 TRENDS IN ACREAGE, YIELD (lbs.) AND PRODUCTION (tons) OF MAJOR CROPS IN BIST DOAB, 1951-52 TO 1968-69

	1951-52			1955-56			1960-61			1968-69		
	Acreage	Yield	Production	Acreage	Yield	Production	Acreage	Yield	Production	Acreage	Yield	Production
Wheat	573,000	960	245,000	614,700	800	219,500	646,300	950	274,000	862,000	1,825	699,000
				(7.2)	(-16.6)	(-10.7)	(12.7)	(-1.0)	(11.5)	(50.3)	(90.1)	(184.4)
Gram	138,800	800	49,600	236,400	550	58,000	218,000	750	73,000	57,000	650	12,000
				(70.3)	(-31.2)	(16.9)	(57.0)	(-6.2)	(47.2)	(-59.0)	(-18.7)	(-75.8)
Rice	43,000	600	11,700	65,000	1,200	35,000	123,000	1,350	74,000	161,000	1,250	86,000
				(51.2)	(100.0)	(199.1)	(186.0)	(125.0)	(532.5)	(274.4)	(108.3)	(635.0)
Maize	173,000	1,050	81,000	192,000	1,030	89,000	237,000	1,100	116,000	356,000	1,200	183,000
				(11.0)	(-1.9)	(10.0)	(37.0)	(4.8)	(43.2)	(106.0)	(14.3)	(126.0)
Pulses	29,000	-	4,500	31,500	-	-	25,000	-	-	17,000	-	2,700
				(8.6)			(-13.8)			(-41.4)		(-40.0)
Sugarcane	84,000	2,500	94,500	76,800	1,965	67,500	100,000	2,500	112,000	87,000	2,400	100,000
				(-8.6)	(-21.4)	(-28.6)	(19.0)	(0.0)	(18.5)	(3.6)	(-4.0)	(5.8)
Cotton (*desi*)	30,800	160	2,200	28,000	125	1,175	28,000	230	2,800	2,300	185	2,000
				(-9.1)	(-21.9)	(-28.4)	(-9.1)	(43.7)	(27.3)	(-92.5)	(15.6)	(-9.1)
Cotton (American)	1,200	125	70	12,000	145	800	16,000	200	1,500	4,500	240	400
				(900.0)	(16.0)	(1042.8)	(1233.3)	(60.0)	(2042.9)	(275.0)	(92.0)	(471.4)
Groundnuts	11,000	500	2,500	17,500	700	5,500	24,500	800	9,000	119,000	800	42,600
				(59.0)	(40.0)	(120.0)	(122.7)	(60.0)	(260.0)	(981.8)	(60.0)	(1604.0)
Potatoes	2,300	9,200	9,500	3,500	12,850	20,000	9,800	10,500	65,000	25,500	10,700	130,500
				(52.2)	(396.7)	(110.5)	(326.1)	(141.3)	(584.2)	(1008.7)	(163.0)	(1273.7)

Figures in parenthesis indicate percentage change over 1951-52

Source: Statistical Abstracts of Jullundur, Kapurthala, Hoshiarpur and Punjab, various numbers the new innovations connected with the wheat-production mix. Increasing demand for wheat, nationally and internationally, could not be discredited as a factor for this breakthrough.

Spatially, the expansion of wheat acreage (45 per cent of the occurrences) has a wide distribution (Fig. 15.2), but the gains have been more prominent in areas where either the ecological conditions are best met or where there is no strong competition from other crops, especially cash crops. Largely, these gains have been below 10 per cent, but gains ranging between 10 and 20 per cent of the harvested acreage, and more, have also been observed and form a substantial proportion of the occurrences. The high gains are largely confined to areas where self-controlled assured supply of water is available.

The losses, on the other hand, have been below 20 per cent (largely below 10 per cent) of the harvested acreage, and are confined to specific locations. For instance, wheat has suffered losses of 10 per cent or even more of the harvested area in Bet tracts, where, for ecological considerations, rice emerges as the most important crop. Similarly, the losses in wheat acreage occurred in the rainfed parts. Around urban centres, the acreage under wheat has declined for it has to meet a strong competition from other crops, such as vegetables, sugarcane (around processing centres) and oilseeds (in Dona tract). Some 20 per cent of the observations exhibit a stable situation in wheat cultivation, and are largely scattered throughout the Doab. It also includes areas of no cropping.

<u>Wheat/gram</u> Wheat/gram (mixed) has been a declining crop during the period under review. With assured water and ready availability of modern inputs, wheat/gram has largely been replaced by wheat in pure stands or by other cash

crops. These losses have been considerable (Fig. 15.3). Just under 20 per cent of the observations have recorded gains, largely under 10 per cent of the harvested acreage. These gains occurred either in rainfed parts, where modern technology is far away or in areas where traditional practices are dominant. An interesting aspect is presented in some areas close to the urban centres, where wheat/gram crop has had fair gains. This may be explained in terms of the utility of the crop, that is, grams are generally taken out from the standing crop and sold for cash in the urban market as a green vegetable, while wheat provides the cereal crop for domestic uses.

Gram Gram (in pure stand) has largely been a crop of the rainfed subsistence parts of the Doab, where it still survives. Over most of the Doab, the crop has almost suffered losses (Fig. 15.4). Gains are confined to parts of Garhshanker (significantly in Bit-Manswal tract), Kapurthala, Nakodar and Phillaur tahsil. Indeed, the crop has largely disappeared from the agricultural scene of the Doab.

Rice Though Punjab is not a major rice-producing region, it contributes a substantial amount in the national rice procurement. During the period, Bist Doab has experienced great changes in the cultivation of rice. By 1968-69, rice has trebled its acreage, doubled its productivity and increased production by about six times from the base level of 1951-52. The spatial distribution of changes in rice (Fig. 15.5) reveals both gains and losses, though the gains are substantial in both extent and areal coverage, the losses are small and limited.

The factors contributing to the expansion in rice cropping include expansion of irrigation, extension of waterlogging and flooding, new high-yielding rice varieties, and the presence of experienced rice-growers, who settled in these areas after the Partition (p. 94). The spatial distribution of changes in rice cropping (Fig. 15.5) demonstrates that the expansion in rice cropping has occurred in areas where the above conditions are ideally met or where other crops could not have been profitably grown.

Largely, these gains have been below 10 per cent (Bet of Kapurthala and parts of Jullundur, Hoshiarpur tahsil and Rakkar of Dasuya tahsil) of the harvested acreage. In Phagwara, Bet of Dasuya and parts of Dhak of Nawanshahr and Sirwal of Garhshanker, these gains range between 10 and 20 per cent or even more of the harvest. On the contrary, the losses have been below 10 per cent (largely below 5 per cent) and occurred in isolated patches.

Maize The overall performance of maize has not been substantial, compared with rice or wheat. The increase in production (126 per cent) has largely been the result of increased acreage (106 per cent) under maize. Improvements in productivity, which has practically remained stable, still awaits a breakthrough. Traditional varieties dominate excessively, hybrids accounting for only 4 per cent of the crop in 1968-69. The reasons for non-adoption seem to confirm the view that:

> H.Y.V. maize is more dependent than wheat on massive doses of fertilizer, pesticide and water. It also requires more labour, and provision of all four increased inputs may cost a farmer Rs 1,000 per hectare. Furthermore, the yield difference between H.Y.V. and desi [local] varieties is much less than in the case of wheat and the H.Y.V. is longer duration than desi [local] maize.
>
> (Harriss, 1972)

The spatial distribution of the changes in maize (Fig. 15.6) reveals that the gains have been substantial, while the losses have been limited, both in scale and coverage. These losses have occurred mostly in places where, as a result of ecological changes, rice has emerged as an important crop (cf. Figs. 15.5 and 15.6). One fifth of the observations exhibit losses in maize cropping, largely below 5 per cent of the harvested acreage. A similar proportion of the observations have shown stable situation.

The gains in maize cropping have a wide distribution, comprising three fifths of the total observations; high in eastern parts and Bet of Nakodar, largely ranging between 5 and 10 per cent or even more of the harvested acreage. Elsewhere, the gains remain largely under 5 per cent of the harvest.

Pulses Traditionally, pulses have played an important part in the local ecology in the past. With increased specialisation, all dry crops, including pulses, have almost disappeared from the agricultural scene of the Doab or, for that matter, Punjab. In the drier parts, however, the pulses have gained modestly (Fig. 15.7), largely below 5 per cent of the harvested acreage. A similar increase is observed in isolated patches in Jullundur district where it may be considered as a traditional backlog. The losses comprise almost twice the occurrences than the gains, largely under 5 per cent of the harvested acreage, and exhibit scattered distribution.

Fodders The spatial distribution of changes in fodder acreage (Fig. 15.8) reveals both gains and losses. The gains have been largely under 10 per cent of the harvested acreage and are confined mostly to Hoshiarpur district and Bet of Kapurthala - largely a region of subsistence agriculture. Around urban centres, to an extent, these gains are over 10 per cent of the harvested acreage. These gains may be explained largely in terms of (a) increasing demand for fodder in the urban markets; and (b) reduction of grazing facilities (consequent to reclamation of land for agricultural purposes) and subsequent increase in demand for cultivated fodders.

The losses on the other hand, are confined to Jullundur district and Phagwara tahsil - mostly a region of specialised farming, where mechanisation of various farm operations has been very rapid during the decade 1960-1970. In parts these losses have been below 5 per cent, while in Dona, Manjki, Dhak and Retli tracts, the losses range between 5 and 10 per cent or even more. It may be pointed out that despite these losses, these areas exhibit higher proportion of acreage under fodder (Figs. 10.14 and 11.10).

The following explanations can be offered for these losses. First, the losses in fodder acreage may partly be attributed to intensive cropping, that is, raising two or even three crops from the same field as opposed to one crop in a year. By doing so the farmer is reducing the proportion of his allocation to fodder crops, but at the same time producing enough fodder to meet his livestock requirements. Secondly, the mechanisation of various farming operations might have reduced the number of livestock, especially draught force, thereby reducing the fodder requirements. Thirdly, the growing of crops like <u>jowar</u> and <u>bajra</u>, which had been a source of both dry and green fodder in the past, have almost disappeared mainly because the demand for dry fodder can be met from other cereal crops (as the intensity of cropping has increased considerably). Therefore, the need to grow special fodder crops is limited to green fodder only. Fourthly, to some extent, the availability of commercial concentrates might have had an impact.

<u>Oilseeds</u> Oilseeds, for all intents and purposes, means groundnuts, for these account for over 95 per cent of the total oilseeds produced in Bist Doab. Groundnuts have gained substantially by increasing in acreage by almost 10 times and production by 16 times from the base period (Table 15.1). In terms

of productivity, however, the crop is insignificant, largely because it is raised in the traditional way under rainfed conditions (for more details see Chapter 10)

The localised distribution of the crop has been observed elsewhere (Chapter 10) and the spatial distribution of the changes in oilseeds is presented in Figure 15.9. The gains are localised in Dona tracts of the Doab, where the crop meets ideal environmental conditions. These gains range from under 10 per cent to over 20 per cent of the harvested acreage. The losses, on the other hand, are limited both in scale (under 5 per cent) and coverage. These are scattered throughout the Doab, largely in Bet parts.

Sugarcane Sugarcane has remained relatively static. In acreage it has increased by 4 per cent and in production by about 6 per cent approximately. In terms of yield, the crop has suffered a decline. The main explanation for this largely static situation lies partly in the fact that it has to compete with other cereals and cash crops which yield higher profits, and partly in terms of labour and other input - fertilizers, irrigation water - constraints (for more details see Chapter 12).

Nonetheless, the spatial distribution of the changes in sugarcane exhibits both gains and losses (Fig. 15.10). The gains, largely below 5 per cent of the harvested acreage, are mainly confined to areas lying within the effective zones of the processing centres or those which are easily accessible to road and rail routes. The losses have a scattered distribution, largely in Bet and Dona tracts of the Doab.

Cotton Cotton has never been an important crop of the Doab and only had local significance. Most of the crop is of desi varieties which has persistently exhibited a decline in both acreage and production. Figure 15.11

indicates that over large parts, cotton has suffered losses of up to 5 per cent of the harvested acreage. The gains too are very modest (under 5 per cent) and have a scattered distribution. The main contributing factors hindering cotton cropping have largely been reflected in unsuitable climatic conditions.

Vegetables One notable feature of the post-Independence period has been the emergence of vegetable cropping around urban centres (Fig. 15.12). The factors responsible for increasing concentration of vegetables in these areas include expanding demand from increasing urban population, general improvement in living standards and changes in eating habits of the people (for details see Chapter 12).

The examination of Figure 15.12 reveals that around all urban centres, vegetable cropping has gained. These gains have largely been under 5 per cent, although gains between 5 and 10 per cent or even more of the harvested area have also been observed around major urban centres. The losses, on the other hand, are modest (under 5 per cent) and limited. Spatially, these losses occur in Bet tracts - where farming conditions have considerably deteriorated, and around some towns - where urban expansion has consumed land where vegetables were grown.

Changes in crop-patterns

By crop-pattern is simply meant the proportion of an area under different crops at a point in time. A change in the cropping pattern implies a change in the proportion of area under different crops at two different times. In the preceding discussion, the emphasis has been largely on the changes in individual crops and on changes in intensity of cropping. These analyses provide useful bases for structuring the regional patterns so that the nature and direction of these changes could be seen in a synthesized form. These are best represented in the crop-pattern change regions which form the substance of the ensuing account.

Crop-pattern change regions The data used in this analysis relate to the changes in the relative proportion of acreage occupied by each of the twelve crops for each of the areal units (360 sample villages) for different time periods. Five-year averages, relating to the First and Third Five-Year Plans periods, were used. The averaged data helped remove discrepancies occurring due to weather anomalies and to attain stable and more meaningful patterns and trends of change over the period. Since these changes are relative, they do not necessarily depict the relative overall strength of a crop in a particular area. For instance, a crop in a particular area may show a declining trend but still be the largest crop of the area. Therefore, while studying these change pattern regions, the real nature and aspect of change involved must be clearly understood. Further, these crop-pattern change regions would prove more useful if considered and studied in collaboration with the crop-pattern regions which have emerged as a result of these dynamic change processes over the time period involved in this study (Chapter 13).

The crop-pattern change regions were derived in the same way as explained earlier (p. 250). Six regions were obtained which provided a synthesis of the major patterns of changes which occurred during the period under review, in the Doab. The spatial distribution of these is shown in Figure 15.13, and summary statistics are given in Table 15.2. To examine the relationships between the regions, a multidimensional scaling procedure was used. This is exhibited in Figure 15.14 and can profitably be used together with Table 15.2 in analysing these regions

TABLE 15.2 PERCENTAGE CHANGES (MEAN VALUES) IN CROPPING PATTERNS IN VARIOUS CROP-PATTERN CHANGE REGIONS: 1951-56/1961-66

Region	Frequency	Wheat	Wheat/gram	Gram	Barley	Rice	Maize	Sugarcane	Cotton	Fodder	Pulses	Oilseeds	Vegetables
I	116 (32.2)	-0.10	0.94	-0.35	-0.06	1.68	0.74	-0.13	-1.73	0.80	0.07	-0.37	0.17
II	47 .(13.0)	-5.77	-0.40	-1.11	-0.01	-0.43	10.06	-0.56	-0.85	0.51	0.10	-0.75	0.11
III	19 (5.3)	-6.55	-6.38	-1.20	-0.05	19.65	-3.17	0.75	-0.11	0.30	-0.85	-0.66	-0.17
IV	79 (22.0)	6.51	-6.50	-1.98	-2.06	0.67	3.84	-1.63	-5.27	6.08	0.26	1.40	0.22
V	59 (16.4)	9.43	-17.97	-0.14	-0.04	1.74	6.82	-0.28	1.68	0.05	-0.11	-0.45	1.64
VI	40 (11.1)	-17.20	5.50	0.69	0.02	5.55	0.50	0.43	2.54	0.89	0.74	-0.79	1.12
Overall	360 (100.0)	2.06	-3.85	-0.70	-0.05	2.40	3.40	-0.43	-1.27	1.78	-0.11	0.50	0.50

Figures in parenthesis indicate frequency percentages

In regions V and VI, on the extreme left and right, the major shifts have been in winter cereals. The former depicts considerable gains in wheat and losses in wheat/gram, while the latter presents a converse situation. Again, the two extremes on top and bottom (regions II and III), reveal main shifts in summer cropping. Region II has gained substantially in maize while rice has declined, while region III is the other way round. Between these extremes, lie regions I and IV which present a different change pattern altogether. Region I is characterised by a stable pattern, whereby no crop has significantly changed. Region IV is more of a diversified change pattern in which most of the crops are involved in change, principally wheat, wheat/gram, maize, fodder, cotton and sugarcane.

The spatial pattern produced by these regions is fragmentary and complex. This emphasizes the considerable spatial variation in agriculture of the Doab - a general feature of farming for the whole of Punjab. Yet, these patterns reflect the general trends of the change-patterns observed earlier. Since the emerging crop pattern regions are the net results of the changes which occurred during the period under review, a close relationship, as expected, between the crop-pattern change regions and the crop pattern regions is clearly visible (cf. Figs. 15.13 and 13.19). These relationships will be identified more closely in the following discussion on the individual crop-pattern change regions.

Region I is the largest, comprising about one third of the total occurrences. It is characterised by stability of cropping pattern whereby no crop has significantly changed during the period under review. Spatially, it has three distributions, each representing a different aspect of stability. Its largest concentration is in the central parts of the Doab - largely a region of commercial farming where environment presents balanced farming conditions. This stable pattern of areal coverage is by no means indicative of the production-mix. It has been observed earlier that these parts have achieved high intensity of cropping by way of multiple cropping and have added considerably to the out put potential of these parts. For instance, a farmer who had been growing wheat in 5 out of 10 acres in the past may have slightly adjusted his allocation plan, so that, although he may still have the same acreage under wheat crop, he may produce 2 to 3 times more grain because of high yields obtained from the new strains. The second concentration is in the rainfed eastern parts, where environmental limitations have been, and still are, a major deterrent to any significant change in the crop structures. The third concentration is in the north and west of the Doab, where natural hazards such as waterlogging and flooding restrict the choice of crops. Therefore the general pattern of cropping remains unaltered. Since the region has a wide distribution it corresponds with various crop regions - largely with region VII (wheat, fodder and maize) and region VIII (diversified).

Region II accounts for 13 per cent of the occurrences and is characterised by highly significant expansion in maize. The main declining crops are wheat and rice. Other crops remain virtually unchanged. The region presents a scattered distribution, largely confined to rainfed areas and some locations along river Sutlej. These areas exhibit high concentration of maize, largely grown for domestic cereal consumption. It also occurs around urban centres, where the crop is raised for cash sale in the market. The region corresponds with region IV (wheat, fodder and maize) elsewhere.

Region III is the smallest (comprising 5 per cent of the occurrences) and is characterised by significant increases in rice. The important decreasing crops include maize, wheat and wheat/gram. Sugarcane has gained but modestly. The region exclusively corresponds to the rice region (I). The factors favouring the change pattern include the physical conditions - availability of irrigated water, frequent flooding and waterlogging - and the human responses.

Region IV exhibits relatively well-defined spatial pattern; comprises over one fifth of the occurrences largely in the central parts of the Doab. It has a diversified change pattern which involves most of the crops. The main increasing crops include wheat, fodders and oilseeds, while wheat/gram, cotton, barley and gram are the leading decrease crops. Maize remains largely stable. Indeed, the general trend has been in favour of wheat and fodders. This is exemplified in Figure 13.9. The region corresponds largely to region VII (wheat, fodder and maize) and in parts to wheat regions (II). The impact of new developments is largely reflected in these parts.

Region V accounts for over 16 per cent of the occurrences, largely concentrated in new well-irrigated parts of Sirwal tracts of the Doab and around urban centres. In the Sirwal tracts, wheat has increased substantially and in fact has replaced wheat/gram - a crop which has experienced maximum losses in these parts. Around urban centres, the change has been mainly directed towards vegetables and maize (due to its various uses) largely in response to market incentives. Most of the other crops have remained virtually stable. The region corresponds largely to diversified farming region (VIII).

Region VI comprises over 11 per cent of the occurrences and has a scattered distribution, largely in Bet of Dasuya and Kapurthala. The most significant increase crop is wheat/gram while wheat is the leading decrease crop. This shift can mainly be attributed to the emergence of rice in Bet areas, which affects the timing of wheat sowing in the rice fields in many ways. For example, wheat requires well-prepared field with balanced soil moistures. Both of these normally do not coincide with the rice cropping. Generally, harvest of rice crop is delayed - sometimes due to late sowing of the crop and often due to the fact that the rice fields are not dry enough to permit the harvest. Under these conditions, wheat/gram is the best bet of the farmers. Rice, cotton, sugarcane, vegetables are the other increasing crops. The region largely corresponds to the rice region (I).

TRENDS

In the central Doab, assured and self-controlled supply of irrigated water, developed means of transport, ecological suitability, market incentives and conscientious efforts of the farmers have played their significant roles in evolving a cropping pattern leading to secure, stable and increasing specialisation of a limited range of crops. These include: among cereals, wheat and maize; among specialised crops, vegetables and fodder around urban centres; among industrial crops, oilseeds (groundnuts) in Dona tract and sugarcane around processing centres. With the expanding demand and increasing use of high-inputs, these trends can be expected to lead to further specialisation. The expansion of vegetables around urban centres is more imminent. The stability of sugarcane and oilseeds trends, however, will largely depend on the price and profit structures of these crops in relation to others as well as the official policies of the government in future.

In the eastern parts, largely rainfed, the overall crop patterns have remained more or less unchanged. There is little reason to suspect that the current pattern of stabilization in most of these areas will be altered radically in the near future, with the exception of Sirwal tracts where recent developments in tube-well irrigation are bound to have a significant impact. The topography of the eastern hilly parts, for the large part, is a serious deterrent to irrigation and hence agriculture. Moreover, ground water is too far below the surface to permit easy exploitation.

The Bet areas on the south and west - largely waterlogged and susceptible to flooding - present a deteriorating agricultural environment and, therefore, restricts the choice of crops. These areas largely remain cereal growing and can be expected to remain so unless the agricultural environment is radically improved.

The general trends, however, are indicative of (i) a shift from low-value crops to high-value crops which are high-input based; (ii) a tendency towards increasing intensity of cropping; and (iii) inter-regional variations in overall agricultural development. These reflect the overall trends in Punjab or for that matter in India as such.

CONCLUSIONS

Regional trends in the patterns of change observed earlier (Chapter 14) have been largely reinforced in this chapter, and the underlying forces inducing such change patterns have been identified. These forces stem from the interaction of new inputs and outputs, new implements and power sources, new cultural practices, irrigated water, and above all the human ingenuity. Expanding population coupled with increasing demands - national and international - for cereals cannot be discredited.

In response to these forces, the intensity of cropping has increased over most of the Doab, though the central parts have gained more. Two general shifts in cropping have been recognised: (i) a shift from low-yielding-drought-resistant crops - gram, barley, jowar, bajra, pulses and cotton (desi) - to high-yielding-water and fertilizer responsive crops - wheat, maize, rice, cotton (American); and (ii) the emergence of new crops such as potatoes, cotton (American), groundnuts and vegetables. The main achievements have largely been among major cereals, wheat remains the most important crop which has had a real breakthrough on all aspects. Rice has had only modest gains while maize has relatively lagged behind. Cash crops, too, are gaining significance.

The regional analysis indicates that inter-regional disparities exist, as expected, and may increase in the Doab as in the rest of Punjab. The rapid growth in agricultural output in the central Doab can be expected to continue - may even more greatly accelerated relative to other parts of the Doab by the dissemination of new, high-yielding varieties of wheat, maize, rice, vegetables and sugarcane. The true potential of these varieties is only realised under high-fertility, high maintenance environment of an irrigated area, which these parts present. Moreover, the significant industrial growth and urbanisation in these parts will continue to aggravate differences. The weaker areas on the east and west will, however, continue as subsistent cereal cropping areas unless a breakthrough is achieved in irrigation, drainage and other related developments.

The dynamic of these patterns, as perceived, is largely high-input based. Water development is critical to any strategy of growth. Equally important are energy sources, fertilizers and pesticides. Therefore, future developments as well as the stability of the present patterns will largely depend on the availability and price structure of these inputs. The vulnerability of the system is, therefore, high and is subject to exterior causes and forces beyond control. Future policies of the government, no doubt, will have a crucial role to play.

These discrepancies can be regarded as the general character of agriculture in Punjab or for that matter in the whole of India. In Punjab, for instance, the best favoured areas lie in the heart of Punjab where agriculture has been transformed radically and which, incidentally, also have a strong small scale industrial base. On all India level, again, Punjab is the leading State. Admitted that some areas are relatively better endowed with physical and economic potentials, yet the main factors permitting or inhibiting change processes or growth processes, is human response itself. This is clearly demonstrated by Punjabi and Haryanavi farmers. Consequently, the accent on dealing with these discrepancies on provincial level or on national level must be on developing the human resource. Care should also be taken, however, that development policies and programmes be concentrated enough to ensure the emergence of a viable centre of economic activity in the area.

CHAPTER 16

TECHNICAL CHANGES: IRRIGATION IN AGRICULTURE

Irrigation is one of the most important and basic ingredient in the process of transformation of agriculture. This is especially so, in India and similar countries, where rainfall is both inadequate and unreliable. It is a primary innovation in itself and also a pre-condition for, and stimulus to, further innovation adoption. Without an assured supply of water, neither the H.Y.V. (High Yielding Varieties) nor chemical fertilizers - the pivots of modern agricultural growth - can profitably be used. 'Although evidence proves that farmers with irrigation facilities innovate quickly, there is none to show the pattern of adoptions amongst dry farmers' (Harriss, 1972). It is further observed that '...generally the possession of irrigation facilities increases the rate of innovation adoption by an average of 14 per cent' (supra). Indeed, this rate of innovation adoption will be much higher in areas endowed with self-controlled assured supply of water. This has been extensively demonstrated by the farmers in Punjab and especially in Bist Doab, where self-operated wells and tube-wells share 89 per cent of the total irrigated area (1968-69).

The role of irrigation in the transformation of Doab's agriculture is assessed in terms of the changes, both qualitative and quantitative, in the sections which follow.

CHANGES IN IRRIGATION

With the progressive increase in irrigation facilities during the past two decades, net irrigated area in Bist Doab was extended from 564,700 acres in 1951-52 to 881,400 acres in 1968-69, exhibiting an increase of 56 per cent. The corresponding figure for Punjab was 41. The gross irrigated area, however, increased more rapidly - from 588,120 acres in 1951-52 to 1,265,200 acres in 1968-69, an increase of 115 per cent, as against 73 per cent for the State as a whole.

Three explanations may be offered for these developments:

(i) In the initial stages, the initiatives and skills of the refugee farmers helped considerably in improving the agricultural landscape by way of diffusing irrigated farm practices in the region. Since they were accustomed to irrigated farming in West Punjab (Pakistan), they could no longer do without irrigational facilities in the Eastern Punjab. They gave a high priority to irrigation as is well expressed in the following paragraph:

> "The first thing we did, once the lands had been allotted to us, was to install tube-wells. We were not used to irrigating from wells, because in Pakistan we had canals. We did not relish the idea of walking round and round with the Persian wheels. One of our men actually fell into the well while doing so. But then there was no electricity here. So we formed a committee, collected 20 rupees per head, and applied for power. Naranjan Singh and Badan Singh were assigned to do the running around in the various offices, and, finally, we obtained the necessary sanction. For tube-wells the government offered loans, not subsidies.
>
> (Nair, 1961: 102)

The element of co-operation, perhaps, stems from bare economic necessity rather than the will. The experience in Punjab bore evidence to the fact that many farmers (often close relations) started with a joint tube-well, but as soon as their economic conditions improved, they constructed a separate tube-well for themselves.

(ii) Due to shortages of food in the country, the planning processes were committed to provide irrigational infra-structure, for it was thought that only irrigation can improve the food situation in the early stages of development. In the early 1950's many large scale irrigation projects were begun, but it was through offering loans and essential services that agricultural production in the State was boosted. A complementary factor was, indeed, a better administrative structure in Punjab than elsewhere in India.

(iii) The availability of both surface and ground-water in large quantities, endowed by the ease of digging wells and installing tube-wells, helped in speeding up the process. To this may be added the impact of locally produced machinery, especially diesel engines and wheat threshers.

The combination of these factors produced an irrigational infra-structure which provided a sound base for agricultural development in the State. This is largely reflected in both the high proportion of irrigated cropping as well as in the better methods and improvements in techniques of irrigation, and, subsequently, higher farm production.

Changes in methods and techniques

In the post-Independence period, changes are observed in two directions, the improvement of the existing methods, and the adoption of better and more efficient methods of irrigation. In the pre-Independence period, wells were virtually the only source of irrigation in the Doab, and the major source of irrigation in Punjab. The water was lifted from these wells by Persian wheels driven by draught animals. Most of these Persian wheels were made of iron, though wooden ones were not uncommon. In addition, some very crude methods such as Jhalars, Dhinglies and Kuls were also used for irrigation. These methods were not only inefficient but their use was very limited. Seasonal canals also shared, though insignificantly, in the total irrigation of the Doab (Table 16.7).

In the post-Independence period, the structural mechanism of Persian wheels was improved to increase their efficiency and the use of other crude methods was gradually abandoned. With the advance in mechanisation in the late 1950's, the replacement of wells by pumping sets and tube-wells was on its way. To begin with, these pumping sets and tube-wells were largely driven by diesel power but at a later date electric power was also utilised. Up to 1969, about 40 per cent of the total tube-wells were operated by electricity in Punjab. Personal observations and inquiries during field work, however, suggests that farmers prefer tube-wells operated by diesel power (though expensive to run) over electricity, mainly because they were not sure of getting regular supply of power at the time when it was most needed. It was also observed that those farmers who could afford it had double arrangements, that is, electric power as well as diesel engines, to secure the assured supply of irrigated water.

On the whole, farmers perceived two main advantages of tube-well irrigation over canals. Firstly, it is self-controlled and, unlike canals, the supply of water is assured. Secondly, water courses are short and consequently percolation losses are small. The tube-wells are virtually always owned by the farmers themselves (Table 16.1). Generally these are shallow, ranging between 25 and 30 metres, with an outlet of 10 centimetres in diameter. The capacity of a tube-well varies from 0.25 to 0.50 cusec. The average construction cost is Rs. 5,000/-. The diesel engines are locally made and have very simple mechanisms. The obvious advantage of these small engines is that they are mostly portable and can easily be used at different sites.

TABLE 16.1 TUBE-WELLS USED FOR IRRIGATION PURPOSES ONLY, 1968-69

Region	Government		Private		Total	
	Number	Per cent of total	Number	Per cent of total	Number	Per cent of total
Hoshiarpur	2	0.04	5,009	99.66	5,011	100
Jullundur	40	0.55	7,196	99.45	7,236	100
Kapurthala	104	6.13	1,593	93.87	1,697	100
Bist Doab	146	1.05	13,798	98.95	13,944	100
Punjab	845	1.33	62,018	98.66	62,863	100

Source: Statistical Abstract of Punjab, 1969

Irrigation, since its inception, had been carried out through open surface channels in Punjab as in the rest of India. This practice is water, land and labour wasting. Yet it survived and is still widely practised. Improvements have been introduced but their impact is still far from being felt. These include (i) brick lining of open surface channels to reduce water percolation, and (ii) the introduction of underground pipe channels.

Changes in the pattern of irrigation

Analysis of the changes in the pattern of irrigation of the Doab involves two elements: the changes in the extent of irrigation (the proportion of net irrigated area to net sown area) and changes in the intensity of irrigation (the proportion of gross irrigated area to net sown area). As such, the extent denotes the areal coverage of irrigation, whereas the intensity is an expression of the effectiveness with which the irrigation facilities are utilized. Although both are, to a high degree, complementary to each other, they reflect different aspects of change. For example, a particular region might have experienced a decline in the extent of irrigation, but that does not imply that the intensity has declined. On the contrary, it may be that with the adoption of better and more efficient methods, the intensity has been enhanced. Similarly, in areas where the extent of irrigation has risen, it does not necessarily follow that a rise in the intensity of irrigation will occur.

The spatial distributions of both, the extent and the intensity of irrigation are presented in Figures 16.1 and 16.2 respectively. From the examination of these maps, the following broad features can be recognised:

(i) Over most of the Doab, an expansion has occurred in both extent and intensity of irrigation during the period under review. It is however, the scale of expansion which differs appreciably in different parts of the Doab. With respect to extent, about half of the observations register expansion: the increases have been largely below 10 per cent though increases of 10 to 20 per cent and over are also observed. In terms of intensity, two thirds of the total observations exhibited increases, largely under 25 per cent while in some parts these increases have been as high as 25 to 50 per cent and over.

(ii) On the losses side, the numbers have been very small, below 16 per cent in both aspects. The losses in extent and intensity of irrigation are recorded in 12 and 16 per cent of the total observations respectively. These are largely confined to (a) degraded land; and (b) areas where agricultural land has been provisionally requisitioned for urban, industrial and allied development projects. Such requisitions restrict the use and future development of the agricultural activity in the area.

(iii) About 38 per cent of the observations in the case of extent of irrigation and 17 per cent for intensity, remained effectively unchanged. These include largely areas of restricted environmental choices or where development in terms of irrigation installations could be risky.

It is interesting, however, to analyse these changes together. The combined frequencies of observations for both changes in extent and intensity of irrigation, have been computed, and are presented in Table 16.2.

TABLE 16.2 A SUMMARY OF CHANGES IN EXTENT AND INTENSITY OF IRRIGATION IN BIST DOAB, 1951-56/1961-66

		INTENSITY		
		increase	no change	decrease
EXTENT	increase	166	6	38
	no change	27	45	12
	decrease	49	1	14

Total observations 360

Figures in the cells denote frequencies

The most important and meaningful category in terms of agricultural development is of expansion in both the extent and the intensity of irrigation. This implies not only that more areas have been brought under irrigation but also shows that the irrigation facilities are more effectively and efficiently utilized. It also indicates that the farmers in these areas are making a concerted effort to produce more by practising multiple cropping. The category accounts for 47 per cent of the total observations. On the basis of scale of expansion, it can be sub-divided into two: (i) high expansion and (ii) moderate expansion. In the first case, the rate of expansion ranges from 10 to over 20 per cent in extent, and from 25 to over 50 per cent in the intensity of irrigation. This is largely observed in Phillaur and Phagwara tahsils and Maira of Dasuya. In the latter case, this rate has been below 10 per cent in the extent and 25 per cent in the intensity of irrigation. Spatially, these include Retli, Manjki and Sirwal tracts of the Doab. Most of these areas saw profound expansion in both wells/tube-wells and canal irrigation, during the period under review. It may be relevant to point out here that Nawanshahr, Nakodar, Phillaur and Phagwara constitute a belt which has supplied the maximum number of immigrants to countries like Britain and Canada (p.97). With the improvements in their economic conditions abroad, the situation at home has also improved considerably, as these people have been regularly sending money back home which was largely invested in providing an agricultural infra-structure, especially the installation of tube-wells and the purchase of tractors. Some returned home after earning enough money (John, 1969) to own a good farm in their native villages. They are relatively more progressive and are willing to accept new innovations (personal observations). Reference to Figure 9.1, will amply reveal that these areas have substantially increased the intensity of cropping.

The second major category involves a reduction in the extent of irrigation but an increase in the intensity of irrigation. This comprises 13 per cent of the observations and presents a very scattered distribution. Generally the losses in extent have been small (under 10 per cent), the gains in the intensity have been high, up to 25 per cent - though in some cases it was more. Spatially, this is largely confined to parts of Nawanshahr and Jullundur tahsils, Sirwal of Hoshiarpur district and parts of Dona and Manjki of Nakodar. The probable explanation could be two-fold: (i) more land has been brought under cultivation without any extension of irrigated area, which subsequently reduced the proportion of the net irrigated area to net sown area (the extent of irrigation); and (ii) the existing irrigated lands are being more effectively and efficiently utilized by practising multiple cropping which has enhanced the intensity of irrigation.

Opposed to the above category, is a category of gains in extent but losses in intensity of irrigation. It comprises 10 per cent of the observations and is spatially scattered largely on the margins of Jullundur tahsil and parts of Bet areas of Kapurthala and Dasuya. The losses in intensity, for the most part, have been very small, below 25 per cent, while gains in the extent mostly range between 10 and 20 per cent though some were less than 10 per cent. These areas are in the process of deterioration, largely on account of bad field drainage. Consequently, most of these areas are producing only one crop a year. Largely it is the *kharif* cropping, especially rice, which could stand the adverse drainage. Reference to Figure 9.1, shows that the intensity of cropping has declined considerably in these locations.

The category of stagnation comprises 4 per cent of the observations. This exhibits decline in both extent and intensity of irrigation, and is confined largely to marshy lands at the confluence of the Sutlej and Beas rivers. In fact, this represents areas of virtually no cropping.

The category of no change, comprising about 12 per cent of the observations, includes (i) largely rainfed areas - Kandi and Bit-Manswal of Hoshiarpur district, and (ii) degraded lands in Bet areas. The restricted environmental choice in these areas prevents any appreciable improvements by an individual farmer. The situation demands special government attention which could provide sufficient funds for irrigation and drainage projects. Over 7 per cent of the observations recorded increases in intensity without appreciable change in extent of irrigation. This obviously represents a general feature of overall expansion in the use of irrigation facilities, on account of both better and efficient methods which have provided more secure and intensive irrigation. Spatially, it is scattered largely in Manjki and Dhak of Phagwara, Dona Lehnda of Jullundur, Bet of Kapurthala and Dasuya. Another 3 per cent of the observations register decline in intensity while extent remains unchanged. These are largely degraded lands in a few isolated spots in the Bet areas of the Doab. The main cause again is the general deterioration of agricultural activity in these areas.

On the whole, the changes in the extent and the intensity of irrigation include both gains and losses, but while gains have been considerable, both spatially and in number, the losses have been very small and confined to a few isolated patches. The use of intensity of irrigation in relation to the extent of irrigation is of particular significance, for intensity by and large is an expression of effective use of irrigation facilities. The author has coined and used this expression for the first time, though earlier works have depended entirely on extent of irrigation as a factor in the development of agriculture.

THE EMERGING PATTERNS OF IRRIGATION

Consequent to expansion in irrigation as well as improvements in its methods and techniques, a new dimension in the pattern of irrigation has emerged. This, hopefully, will provide a sound base for future agricultural development in most of the Doab. The focus, here, is on these emerging patterns of irrigation, both overall and seasonal.

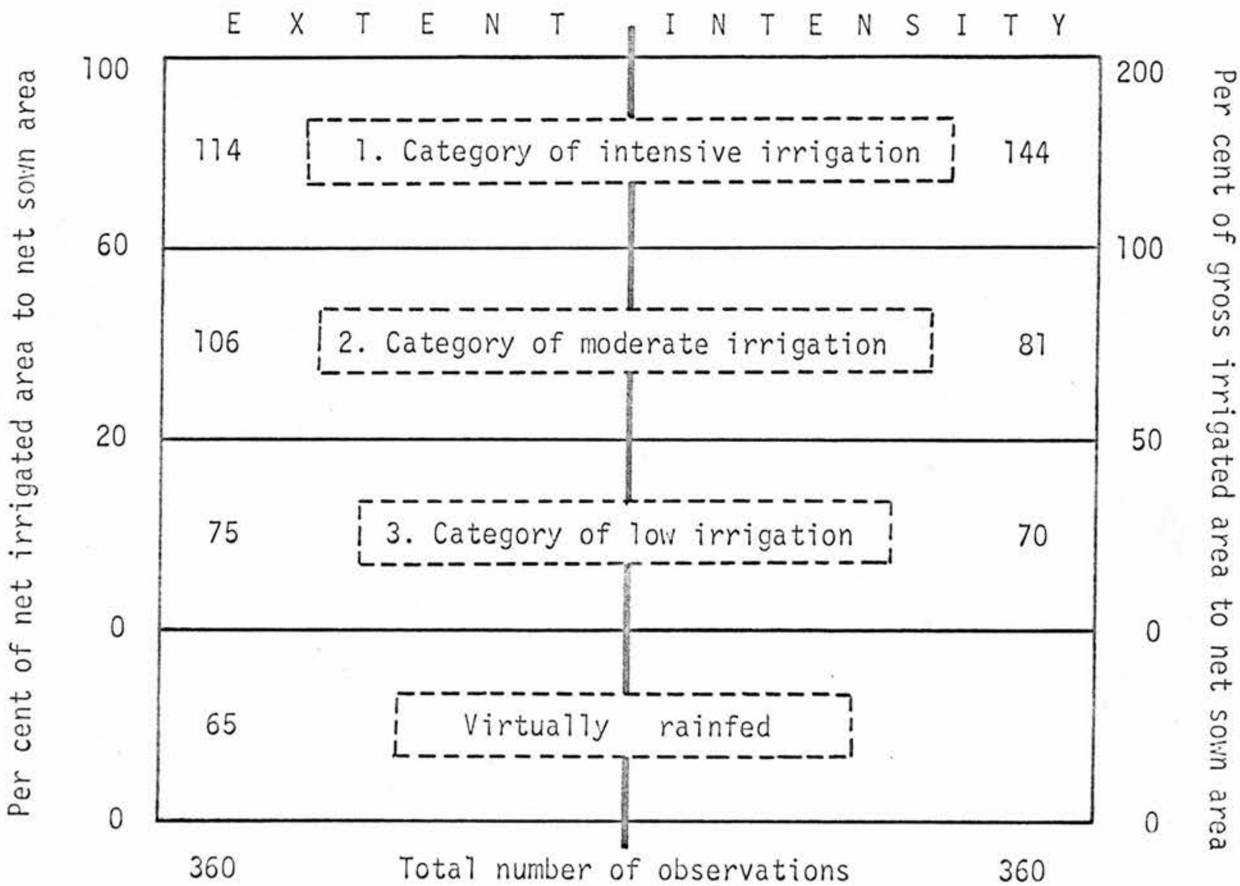
On an average, 55 per cent of the net sown area is irrigated, mostly by wells and tube-wells. Canals share about 6 per cent of the total irrigation. With the improvements in irrigation facilities, multiple cropping is widely practised. Subsequently the gross irrigated area has been enhanced considerably. Out of the net sown area of 1,593,850 acres in 1968-69, the gross irrigated area was 1,265,200. This gave an intensity of approximately 80 per cent. But these aggregative figures do not reveal the areal differences which exist in the Doab.

The spatial distributions of both the overall extent and overall intensity of irrigation are shown in Figures 16.3 and 16.4 respectively. From the joint examination of these figures, three broad categories emerge (Table 16.3).

<u>1. Category of intensive irrigation</u> This comprises the largest frequency of occurrences in both extent and intensity of irrigation. Spatially, it is confined to Bist Doab canal zone in the central parts; <u>Shah Nehr</u> canal zone

in the north; areas around urban centres; and parts of Bet and Sirwal tracts of the Doab. The high rate of irrigation in these areas is attributable to: (i) suitable environmental conditions for a wide range of crops; (ii) a combination of well/tube-well and canal irrigation which provides a stable base for assured and intensive irrigation; (iii) market incentives for specialised crops around urban centres. The combination of these factors permit commercial farming in these areas and therefore the returns are relatively high. The high intensity (ranging between 100 and 200 per cent) of irrigation implies that double cropping is largely practised.

TABLE 16.3 OVERALL EXTENT AND INTENSITY OF IRRIGATION IN BIST DOAB, 1966-68



The figures in the cells indicate frequencies

2. Category of moderate irrigation This is a transitional unit between the intensive and low irrigation and accounts for about one fourth of the total observations; largely Dona and parts of Sirwal tracts of the Doab. These areas comprise mainly areas of extension of irrigation. For the most part, they represented areas which were covered by sand dunes in the past and which have now been cleared and reclaimed. The irrigation facilities are not adequate enough to provide intensive irrigation to the sandy soils of these areas. Reference to Figures 16.5 and 16.9 will reveal that it is the rabi crops which are largely irrigated. The groundnuts, the major kharif crop of the Dona tract is largely grown under rainfed conditions. Since the intensity of irrigation remains below 100, reinforces the statement that only one crop is irrigated in most of these areas.

3. Category of low irrigation The proportion of extent and intensity of irrigation in this category is low, below 20 and 50 per cent of the net sown area respectively. It comprises mainly Sirwal, Rakkar and Kandi tracts in the eastern parts. Elsewhere it is in isolated patches. Mostly these areas represent extension of tube-well irrigation in recent times. The soils are largely sandy and present difficulty in terms of irrigation.

The Kandi and Bit-Manswal areas in the east, and degraded Bet areas in the west are largely rainfed areas. Due to environmental restrictions, these areas have remained static and can be expected to be so for some time in terms of irrigation development or for that matter agricultural development.

Uses of irrigation in crop seasons

Having established the overall extent and intensity of irrigation, the next step is to assess the use of irrigated water in the two main crop seasons, kharif and rabi. Though the general pattern of irrigation in both crop seasons remains almost similar, the contrasts are largely reflected in the crops irrigated, in the sources of irrigation and in the regional differentiation of irrigation in the Doab. These form the substance of the following discussion.

Extent of kharif irrigation The spatial distribution of the extent of kharif irrigation is presented in Figure 16.5. The relative share of well/tube-wells and canals in kharif irrigation is shown in Figure 16.6 and 16.7 respectively. From the examination of these figures, three main categories can be recognised (Table 16.4).

TABLE 16.4 EXTENT OF KHARIF IRRIGATION IN BIST DOAB, 1966-68

Category	Per cent of kharif cropping	Frequency of occurrence	Per cent of total occurrences	Source of irrigation
1. Areas of high proportion of irrigation	60-80 and Over 80	130	36.1	Both wells/ tube-wells and canals
2. Areas of moderate proportion of irrigation	40-60	41	11.4	Largely well/tube-well irrigated
3. Areas of low proportion of irrigation	Below 40	97	27.0	Entirely well and tube-well irrigated
	Virtually rainfed	92	25.5	Rainfed

1. Areas of high proportion of irrigation Most of the area exhibits high proportion of irrigation in kharif cropping, ranging between 60 and 80 per cent and over. Spatially, they form most of the central parts, old canal

irrigated Maira parts and parts of Bet of Kapurthala. Over most of the areas, well/tube-wells and canals provide irrigation on perennial basis, though in some parts of Bet of Kapurthala, tube-wells installed by the government have played a significant role in improving the agricultural environment. The major crops irrigated include rice in Maira of Dasuya, Bet of Kapurthala and Phagwara tahsil; maize, sugarcane and cotton in most of Jullundur district. Around urban centres, vegetables are largely irrigated.

2. Areas of moderate proportion of irrigation The category is scattered largely in Dona, Manjki, Sirwal and Bet tracts and comprises only one tenth of the occurrences. The *kharif* crops are partly irrigated and partly rainfed. Wells and tube-wells account for a larger proportion of irrigation while canals share a small proportion, mostly under 20 per cent of the *kharif* cropping. The major crops irrigated are cotton, sugarcane, maize and fodder.

3. Areas of low proportion of irrigation Spatially, the category is confined to two different locations: (i) parts of Dona tract, where 20 to 40 per cent of the crops are irrigated; and (ii) Sirwal and Rakkar tract of Hoshiarpur, where 20 per cent of the *kharif* cropping is irrigated. Wells and tube-wells are the main source of irrigation. Due to topographic and soil limitations, canal irrigation is difficult to provide. The major crop irrigated is maize.

Extent of rabi irrigation The spatial distribution of the extent of irrigation in *rabi* cropping, the share of wells/tube-wells and canals in *rabi* irrigation are presented in Figures 16.9, 16.10 and 16.11 respectively. From the examination of these maps, three broad categories emerge (Table 16.5).

TABLE 16.5 EXTENT OF RABI IRRIGATION IN BIST DOAB, 1966-68

Category	Per cent of kharif cropping	Frequency of occurrence	Per cent of total occurrences	Source of irrigation
1. Areas of high proportion of irrigation	60-80 and over 80	144	40.0	Shared by both wells/ tube-wells and canals
2. Areas of moderate proportion of irrigation	40-60	38	10.6	Mostly wells/ tube-wells irrigated. Canals share a small proportion
3. Areas of low proportion of irrigation	Below 40	116	32.2	Entirely wells and tube-wells irrigated
	Virtually rainfed	62	17.2	

Practically the whole of central Doab, most of Dona and Bet of Kapurthala, and parts of Maira of Dasuya exhibit a high proportion of irrigated cropping. Wells and tube-wells comprise the larger proportion, ranging between 40 and 80 per cent in most of Phillaur, Nawanshahr to over 80 per cent in the rest of the areas. In Maira of Dasuya, however, the entire area is irrigated by canals. These parts are the wheat-growing regions and wheat alone shares about half of the gross irrigated acreage (Table 16.6). Fodders and vegetables are the other two important crops which are wholly irrigated in the *rabi* crop season.

Areas of moderate irrigation are few and scattered, largely in Dona and Bet tracts. Wells and tube-wells are the main sources of irrigation, which provide supplementary irrigation to crops such as wheat, fodder and sugarcane.

About one third of the observations exhibit low proportion of irrigation in rabi cropping. It includes mainly hilly eastern parts and some degraded lands in the Bet areas. Wells and tube-wells are the only sources of irrigation. The main crops irrigated are wheat and fodders.

TABLE 16.6 SHARE OF IRRIGATED CROPS IN BIST DOAB, 1968-69

Crops	Per cent of gross irrigated area
Wheat	47.3
Gram and barley	1.4
Maize	15.8
Rice	10.8
Sugarcane	5.4
Cotton	1.7
Others	17.6

Source: Statistical Abstract of Punjab, 1969

TRENDS

During the period under review, the expansion in irrigated acreage has been substantial. Recently, massive tube-well programme being undertaken as a basis for increasing output rather than as a response to the water-logging and salinity problem, have had a real breakthrough (Table 16.7). The gross irrigated area for the years 1951-1968 is plotted in Figure 16.12. Yet, this overall trend does not tell the true story. Indeed, the regional trends are more marked in Bist Doab than elsewhere in Punjab.

TABLE 16.7 TRENDS IN EXTENT OF IRRIGATION (BY SOURCE) IN BIST DOAB, 1951-68

Source	Per cent of net irrigated to net sown area			
	1951-52	1955-56	1960-61	1968-69
Canals	1.91	2.37	2.62	5.95
Wells/tube-wells	35.04*	39.76	40.66	49.15**
Others	0.21	1.53	0.89	0.20
Total	37.16	43.66	44.17	55.30

* entirely well irrigated
** largely tube-well irrigated

Source: District Statistical Abstracts, various numbers.

The more dynamic areas of the central Doab have made considerable achievement in terms of irrigation. This is chiefly on account of the physical, locational, economic, and social factors. These parts present a well balanced combination of canal, well and tube-well irrigation. It may be expected that further intensification and efficiency in the irrigation system in these areas will continue since they have the potential for a more productive and specialised cropping structure. In the western parts, the general deterioration of the agricultural environment leading consequently to uneconomic returns from land may deter further development in irrigation infra-structure. The hilly parts in the east, present certain physical limitations to any significant development in irrigation. In most of the areas, ground water is too far below the surface to permit easy and economic explloitation. These areas, for the most part, will remain unaltered for some time to come.

However, the urge to adopt new HYV with the combined use of chemical fertilizers and pest control measures, may well mean expansion of irrigation in general, and specifically in those areas where it is physically possible and economically sound. Yet, the general shortages, nationally and internationally, of fuel and energy (oil and electricity) and the high prices will affect considerably the future course of these developments, especially in areas of scarce resources.

CONCLUSIONS

In the post-Independence period, some major developments in the patterns of irrigation have been recognised. The expansion in irrigated acreage has been substantial in the Doab as in the rest of Punjab. Moreover, the sources and techniques of irrigation have also improved in terms of efficiency and reliability. Mechanised irrigation in the form of pumping sets and tube-wells have helped considerably in improving the agricultural land resource and farm-production mix. The diversification of cropping by sowing mixed crops has largely been replaced by pure stands of crops. With irrigation, it was also possible to introduce new and specialised crops in the region. To maintain <u>barani</u> large holdings extensively cultivated has been no longer essential 'survival insurance'. Rather, the possession of irrigated acres has become the key for agricultural success and prosperity.

Despite the abundance of both ground and surface water resource, a marked regional differentiation exists and is expected to persist in the near future. The central parts are endowed with an excellent combination of wells, tube-wells, and canals which provide a stable and sound base for intensive irrigation. The eastern parts are largely rainfed and offer relatively much less in terms of agricultural development or, for that matter, irrigation development. The western parts, however, are largely well and tube-well irrigated but due to the deteriorating agricultural environment, offer moderate irrigation facilities. These contrasts are largely reflected in the intensity of cropping and cropping structures, and to a great extent, explain the regional constrasts in landuse and cropping observed earlier. The actual landuse and cropping patterns in the case studies of villages and farms (Chapter 12) confirms the rather obvious hypotheses: (i) that the intensity of cropping is directly related to intensity of irrigation; and (ii) that the intensity of irrigated cropping is directly related to distance from the source and type of irrigation. During the field studies it was also observed that the general trend has been largely in favour of power-operated tube-well irrigation for reasons of economics, reliability, control, efficiency and convenience.

The implications are for increasing dependence on power-operated implements. Considering the recent energy crisis, nationally and internationally, much will depend on the capacities and capabilities of government to procure and supply these increasing demands for energy. Indeed, the availability and price mechanism of these fuels will shape the future course of irrigation development, especially self-controlled assured irrigation, in northern India which has contributed substantially in improving the food situation of the country. Water remains the single most important catalytic factor in explaining agricultural development and change; and water development indeed, will remain critical to any future strategy of agricultural development in Punjab as in the rest of India.

CHAPTER 17

TECHNICAL CHANGES (II): OTHER AGRONOMIC CHANGES

Other agronomic changes are many and include institutional and structural changes in the form of consolidation of holdings and reformation of land tenure system, the progressive introduction and adoption of new inputs such as HYV seeds, pesticides, and fertilizers, the use of power-operated agricultural implements, increased utilization of farm labour, and improvements in road transport, storage, marketing, banking and credit facilities. The motivation of these changes was primarily to provide a base and encourage other changes to transform the agricultural scene in Punjab.

i) Institutional and structural changes: land reforms

The responsibility for the formulation of policies of land reforms, enactment of suitable legislation and its implementation lies primarily with the State government. However, in view of the importance of land reforms in the agricultural production programme and consequently the national economy as a whole, a comprehensive land policy at a national level was enunciated in the First Plan which was later elaborated in the Second Plan and reiterated in the Third and Fourth Plans. This land policy presented a common approach with two specific objectives: First, to remove such impediments to the increase of agricultural production as arise from the agrarian structure inherited from the past; Second, to eliminate elements of exploitation and social injustice within the agrarian system, to provide security for the tiller of the soil, and to assure equality of status and opportunity to all sections of the rural population.

In response to these initiatives, various land reform measures were carried out in Punjab, as in the rest of India. The issue of implementing these reforms has been largely subject to controversy in the past and continues to be so to the present. Despite various errors and omissions in implementing legislative measures there have been substantial achievements, although they vary from State to State and from one policy to another. However, the record of accomplishments of Punjab in most of these programmes has been unique.

Consequent to the land reform measures in Punjab, intermediary tenures were abolished, tenants with right of occupancy became proprietors, land rents were fixed, and legislative protection was ensured to the tenants (for details, see section on 'system of land tenure' in Chapter 7). In addition, two ambitious land reform programmes - ceiling on land holdings and consolidation of land holdings - were also carried out in Punjab simultaneously. The impact of these programmes has been significant in the expanding agricultural economy of Punjab.

<u>Ceiling on land holdings</u> In pursuing the objective of social justice, the programme of redistribution of land by effective enforcement of a ceiling on land holdings was first enacted in 1951 and later amended. In accordance with the provisions of <u>The Pepsu Tenancy and Agricultural Lands Act</u> (amendment 1962), 1955:

> 3.(1) 'Permissible limit' for the purposes of this Act means thirty standard acres of land and where such thirty standard acres on being converted into ordinary acres exceed eighty acres, such eighty acres:
>
> 5.(1) Subject to the provisions of this section, every landowner owning land exceeding thirty standard acres shall be entitled to select for personal cultivation from the land held by him in the State as a landowner any parcel or parcels of land not exceeding in aggregate area the permissible limit and reserve such land for personal cultivation by intimating his selection in the prescribed form and manner to the Collector:

Provided that in making such selection, the landowner shall include to the extent of the permissible limit, all land which he held for personal cultivation immediately before the commencement of the President's Act.

32-A.(1) Notwithstanding anything to the contrary in any law, custom, usage or agreement, no person shall be entitled to own or hold as landowner or tenant land under his personal cultivation within the State which exceeds in the aggregate the permissible limit.

But these statutory provisions were not free from loopholes as is evident from section 32-K.(1) of the Act:

32-K.(1) The provisions of section 32-A shall not apply to--
(i) orchards where they constitute reasonably compact areas;
(ii) specialised farms engaged in cattle breeding, dairying or wool raising;
(iii) sugarcane farms operated by sugar factories;
(iv) efficiently managed farms which consist of compact blocks on which heavy investment or permanent structural improvements have been made and whose break-up is likely to lead to a fall in production;
(v) lands belonging to registered co-operative societies formed for the purpose of co-operative farming, provided the land owned by an individual member of the society does not exceed the permissible limit; and
(vi) where a landowner gives an undertaking in writing to the Collector that he shall, within a period of two years from the commencement of the Pepsu Tenancy and Agricultural Lands (Second Amendment) Act, 1956, plant an orchard in any area of his land not exceeding ten standard acres, such area of land.

In practice, landlords have freely used these provisions to evade ceiling laws through partitions, fake deeds and malafide transfers and a variety of other such arrangements. Yet, despite these obvious evasions and forced evictions

... an area of 177,796 acres was declared surplus up to 30 September, 1970. As a result, 26,088 eligible tenants were settled on 63,422 standard acres. Some 20,910 standard acres and 1,936 ordinary acres have been purchased by landless tenants. About 98 per cent of the cases involving surplus area have been decided and 66 per cent of the surplus area has been used for the resettlement of eligible tenants.

(Randhawa, 1974: 47)

Consequently, most landowners took up cultivating their own holdings rather than taking the risk of leasing out. In addition, 647,740 occupancy tenants were given proprietory rights over an area of 1,850,489 acres. The result was that absentee landlordism declined considerably, occupancy tenants disappeared completely and the proportion of tenants was reduced (Table 17.1).

TABLE 17.1 PER CENT CHANGES IN THE AREA CULTIVATED BY OWNERS AND TENANTS IN PUNJAB

	Percentage of area cultivated		
Description	1946-47	1956-57	1969-70
i) Owner cultivated	51.40	66.40	80.89
ii) Tenant cultivated	47.20	32.50	19.11
iii) Occupancy tenant operated	9.90	4.60	0.00

Percentage does not add up to 100 as categories overlap

Source: Randhawa, 1974: 47

Moreover, in accordance with the land reform measures, tenants, having lost their traditional benefits and obligations, could secure legal protection in claiming their rights over the land they had been tilling for generations. In fact, many such instances have occurred in Punjab where tenants challenged the landlords in the courts and resisted all sorts of pressures including use of physical force or/and harassment by the police. Above all, there was infused a new spirit of dignity and prestige among the rural masses and a new thinking in the minds of the cultivators which resulted in a new relationship based on equality of status and a sense of partnership between the landowners and the tenants - a break away from the centuries old traditional relationship of a master and a servant.

Consolidation of holdings From the point of view of agricultural production, an important programme is consolidation of fragmented holdings. The work was started during the British Period in 1920 through Co-operative Consolidation Societies, but progress was negligible. In the post-Independence period, legislation was enacted throughout India and programmes of consolidating holdings were taken up. In Punjab, East Punjab Holdings - Consolidation of Holdings and Fragmentation Act was enacted in 1948. Progress was rapid and, by 1966-67, Punjab completed this massive programme of consolidation of holdings when other States were a long way behind (Fig. 17.1). The total expenditure as noted in the official files in the composite Punjab (Punjab and Haryana) was Rs 145,330,000 - the cost per acre ranged between Rs 18.00 to Rs 22.00, which was recovered in full from the landowners.

As a part of the scheme, provisions were made for the expansion of Abadi (settlement), reservation of land for community uses such as school buildings and play-grounds, community centres and places of worship. A network of roads was provided linking villages to each other and to the main roads, together with access roads to individual holdings as well as the provision of circular roads around each village Abadi. This provided opportunities and links to the rural population and for the movement of rural goods. The impact of these provisions is reflected in the expansion of the agricultural production mix of Punjab. An important feature of the scheme was that the farmers were enabled to sink wells and tube-wells in their compact farms as well as ensure more efficient use of canal irrigated water. The scheme also provided an additional impetus to landowners to cultivate their holdings as well as in reducing land previously wasted in embankments. It also helped in a considerable reduction of faction quarrels and fights.

ii) Adoption of seed-fertilizer-irrigation technology

The profitability of investment in agriculture has been greatly enhanced by the development of seed-fertilizer-irrigation technology which can multiply productivity per man and per acre. Given the powerful demonstration effect of the success of the new technology, the spread of the dwarf varieties was indeed rapid, although it varied from one crop to another. A contemporary feature of this trend has been a large increase in the use of fertilizers and pesticides, a very much greater demand for irrigation water and the use of pumping-sets and tube-wells (Chapter 16), and a fairly widespread tendency to adopt mechanisation of various field operations (infra).

The High-Yielding Variety Seeds Recognising that domestic varieties were unsuitable for the new production techniques made possible by increased fertilizer consumption, improved water supplies, and pest control, Indian scientists, backed by the Rockefeller Foundation, launched a massive effort to develop and introduce new seed varieties that would respond more rapidly to fertilizer and water inputs. A breeding programme was begun and pursued vigorously to adapt high-yielding short-stem varieties of wheat and rice to Indian conditions and to develop hybrids of Indian types of maize and bajra (millets). These projects crystallized successfully and the HYV crops were finally introduced in 1966-67 (for details, see p.368). The contribution made by the agronomists of Punjab Agricultural University, Ludhiana, in successfully evolving the new seeds has been considerable and deserve special credit. The introduction of the HYV programme, indeed, marked the beginning of a new era in the field of agricultural development in Punjab and India.

The programme of high-yielding wheats has been outstandingly successful, and, indeed, the 'green revolution' has so far been a 'wheat revolution'. A modest beginning with about 4 per cent of the total wheat acreage under HYV in 1966-67, gave Punjab a big lead in the adoption of HYV wheats over the rest of the country which was maintained in the years to follow. For instance, by 1968-69, HYV wheats accounted for 58 per cent of the wheat acreage in Punjab. The figure increased to 68 per cent in 1969-70 and 75 per cent in 1971-72 (Fig. 17.2). The proportion of the farmers using HYV seeds also increased substantially, from over 65 per cent in 1967-68 to over 95 per cent in 1969-70. In other wheat-producing States, this proportion has been very low (Fig. 17.2).

The success of rice has been moderate in Punjab as well as in other rice-producing States, mainly because most of the dwarf rice varieties were in the experimental stages. Moreover, rice varieties are highly susceptible to various rust diseases. The new dwarf rice varieties accounted for 2 per cent of the total rice acreage in 1966-67 in Punjab. This proportion increased to 20 in 1969-70 and 33 in 1970-71. In response to the government policy for encouraging rice cropping, backed by the guaranteed minimum price structure, the adoption of new dwarf varieties was boosted with the result that about two thirds of the total rice acreage was planted under HYV in Punjab in 1971-72. This rapid adoption was also facilitated by improvements in the supply of irrigation water and successful research in bringing out better varieties which suited the Punjab conditions. A mention may be made of IR 8, the most favourite variety grown in Punjab. Some new dwarf rice varieties with good yield potentials and short-duration ripening are also in advanced stages of testing.

The hybrid <u>bajra</u>, too, has shown a substantial growth. The adoption has been rapid and by 1970-71 over three fourths of the total crop acreage was under HYV (Fig. 17.2). Although, the crop has a very limited acreage in Punjab, the improvement in hybrid varieties of bajra has been very beneficial to the farmers of the dry areas in Punjab as well as in other parts of the country. Maize gained reasonably in the early years but by 1969-70, it had almost stabilized with under 10 per cent of the total crop under HYV. This low rate of adoption in hybrid maize can largely be explained in terms of high demand for expensive inputs such as fertilizer, water, pesticides, and labour for which the yield difference between high-yielding varieties and desi varieties does not compensate. Consequently profit margins are low and risks greater as compared to wheat or even rice.

The rapid adoption of the new HYV seeds was made possible by the favourable responses of the farmers in Punjab. Indeed, the urge of the Punjabi farmer was so great that the demand for the 'miracle seeds' in the early years reached a point where farmers were willing to pay extortionate prices in the black market. Though HYV wheats were supplied for multiplication to the 'progressive farmer' at the rate of Rs 75/- per quintal, they fetched much higher prices later on. These varieties fetched between Rs 300-500 per quintal generally, though prices as high as 10,000-15,000 rupees per quintal were not unknown in Punjab in the early years (personal observation). Though small shortages of one seed variety or another still persist from time to time, prices have stabilized at official levels.

Application of chemical fertilizers The application of chemical fertilizers has been very limited and the progress has been very slow during the First and Second Five-Year Plan periods in Punjab. It advanced modestly during the Third Plan and the real breakthrough occurred in the year 1966-67 when HYV package was introduced (Fig. 17.3). Since then, increases in the use of chemical fertilizers have been very rapid. It increased from 240,400 tonnes in 1966-67 to 876,000 tonnes in 1969-70 and to 1,694,000 tonnes in 1971-72. Compared with national trends, Punjab has an excellent record of achievements in the use of chemical fertilizers (Fig. 17.3), and leads all other States.

Despite these achievements, the average quantities of fertilizers applied in Punjab are much smaller than those recommended - a common feature of Indian agriculture. Nitrogeneous fertilizers are the most used, largely due to their relative cheapness and availability, but partly because other types are not well known to majority of the farmers. There may, however, be many reasons for these discrepancies including the lack of awareness of

TABLE 17.2 CONSUMPTION AND CROP NEEDS OF PLANT NUTRIENTS IN PUNJAB (kg. per hectare)

	Fertilizer consumption (1969-70)			Fertilizer needs		
District	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Amritsar	36.7	4.7	2.2	83.2	36.2	16.8
Bhatinda	14.0	0.8	0.1	95.6	26.4	11.2
Ferozepur	20.1	2.1	0.5	90.8	25.1	12.0
Gurdaspur	27.9	2.9	1.2	87.4	37.0	18.0
Hoshiarpur	22.2	2.7	1.0	100.6	39.7	16.8
Jullundur	37.5	6.3	1.8	109.6	41.6	19.8
Kapurthala	27.6	4.5	2.3	84.2	35.7	16.8
Ludhiana	39.0	13.8	1.5	104.0	39.0	17.4
Patiala	27.0	4.6	0.0	92.8	33.1	15.6
Ropar	19.8	3.1	0.9	94.2	39.8	17.4
Sangrur	22.0	2.5	0.6	98.6	33.1	15.0

Source: Randhawa, 1974: 125

farmers, high prices, non-availability at the required time, lack of organisation, but the major single factor remains the overall shortage of fertilizers in the country. Randhawa (1974: 124) makes this point very clearly:

> The figure for consumption of nitrogeneous fertilizer in 1969-70 is approximately 50 per cent of the 1971-72 target which itself is about half of the estimated crop needs. Keeping in view the present cropping intensity of 136 per cent and the very real possibility of its rise to 175-200 per cent during the next decade, the estimated fertilizer needs should undergo an upward revision of 33 to 50 per cent.

Use of pesticides With the adoption of new exotic varieties of various crops which are highly susceptible to pests and diseases, the use of pesticides has become an indispensible element of crop-production technology. Yet, not surprisingly, the use of pesticides remains largely curative rather than preventative. The only crop which has attained some level of use of pesticides is cotton, though historically, a limited use has been made in crops such as vegetables and fruit trees which could give good returns despite the use of the expensive pesticides. Under the Plant Protection Programme, aerial spraying of crops with helicopters (almost entirely applicable to cotton) has been introduced since 1965-66. Growers are required to pay only the cost of pesticides (which themselves are very expensive), other charges are borne by the State. The acreage covered under plant protection measures increased from 2,700 in 1960-61 to 10,000 in 1968-69 and has stabilized around this figure up to 1971-72. The subsidy granted by the government for the purchase of pesticides increased from Rs 124,000 in 1960-61 to Rs 2,017,000 in 1967-68. During 1968-69, advance of such subsidy was discontinued. However, in 1969-70 and 1970-71, a sum of Rs 100,000 each was given as subsidy for pesticides and plant protection equipment in the border areas of the State.

iii) Mechanisation of agriculture

One of the major technical developments of the post-Independence period has been the application of mechanical power to agriculture. Although, mechanisation per se in Punjab and elsewhere in India, simply means the use of tractors, and power-operated pump-sets, tube-wells, and wheat threshers, their impact in improving farm-production performances per unit of agricultural land has been considerable. Consequently, their adoption has been rapid. For instance, in 1969 there were 13,000 tractors compared with 5,000 in 1961 - though biased heavily towards larger farmers owning more than 25 acres. The number of pump-sets and tube-wells increased from 13,000 in 1961 (there were none in 1951) to 80,000 in 1969. Wheat threshers, which were non-existent in 1951, overwhelmed the agricultural landscape and numbered 80,000 in 1969. According to one estimate for the year 1970 '... 24 per cent of the irrigated area was serviced by tube-wells and pumping-sets; 50 per cent of the total wheat crop was mechanically threshed...' (Byres, 1972: 107) in Punjab.

Following the use of tractors, came a host of new farm implements including seed-cum-fertilizer drills, various types of ploughs, transport trailers, etc. Simultaneously, many farm implements driven by bullocks were improved, while others were replaced by better and more efficient implements to cope with the new conditions. The use of mouldboard and iron ploughs, seed drills, disk harrows and cultivators may be cited. The number of wooden ploughs remained stable during the period (Table 17.3). Although a decline might have been expected, it may be that no additional wooden ploughs have been introduced while the old ones are still being used for some purposes,

TABLE 17.3 AGRICULTURAL MACHINERY AND IMPLEMENTS IN PUNJAB

	1961	1966	1969*
1. Disk ploughs (tractor)	-	-	2,000
2. Mouldboard ploughs (tractor)	-	-	500
3. Mouldboard and iron ploughs (bullock)	412,000	635,000	650,000
4. Wooden ploughs	674,000	700,000	700,000
5. Disk harrow (tractor)	-	-	5,000
6. Disk harrow (bullock)	..	-	25,000
7. Cultivators (tractor)	-	-	12,000
8. Cultivators (bullock)	..	-	50,000
9. Blade terraces (tractor)	-	-	5,000
10. Hydraulic levellers or land planes (tractor)	..	-	50
11. Seed-drills (tractor)	-	-	1,500
12. Seed-drills (bullock)	..	-	12,000
13. Planters seed and potato (tractor)	..	..	130
14. Planters seed and potato (bullock)	..	..	500
15. Plant-protection equipment (power)	..	-	750
16. Plant-protection equipment (manual)	..	-	20,000
17. Reapers and binders	..	..	40
18. Groundnut harvesters	..	..	30
19. Threshers	..	-	80,000
20. Transport trailers	-	-	10,000
21. Bullock carts	284,000	308,000	500,000
22. Tractors	4,900	10,600	13,000
23. Pumping-sets / tube-wells	13,600	46,000	80,000
24. Sugarcane crushers (power)	1,600	3,200	-
25. Sugarcane crushers (bullock)	73,700	88,800	-

.. practically non-existent

\- data not available

Source: Director of Land Records, Punjab

* Randhawa, 1974: 147

especially for sowing. Other equipment included the introduction of planters, reapers and binders, groundnut harvesters and the use of plant protection equipment, largely a service provided by a government sponsored agency 'Agro-Industries' of Punjab. It has, however, been predicted (Billings and Singh, 1970), other things being equal, that by 1984, 20 per cent of the gross cropped acreage will be tilled by tractors, 60 per cent of the irrigated area controlled by pump-sets and tube-wells, nearly all of the wheat crop will be mechanically threshed, and 50 per cent of the wheat mechanically reaped in Punjab.

Despite the fact that mechanisation has been fast gaining momentum, there have been many arguments against it. The major argument is that it is labour-displacing in a labour-surplus, underdeveloped economy, causing massive unemployment and fostering existing social tensions. On the contrary, the arguments for mechanisation in improving farm-production performances are many and equally justifiable in a food-scarce situation. Labour shortages at peak periods are well known in Indian agriculture and these have been further accentuated in the multiple cropping situation made possible by new inputs. Inevitably, this leads to high wages during peak periods. Forced by labour shortages and increased wages, and encouraged by the initiatives including credit facilities for the purchase of agricultural machinery such as tractors, pump-sets and tube-wells, farm implements, duty free import of gift tractors, subsidies for plant protection equipment, etc. (largely favouring big farmers), provided by the government and other allied agencies, big farmers will inevitably opt for mechanisation. Because the new high-yielding varieties have a short growing period, which permits multiple cropping, there exists a need to reap the corn quickly and prepare the field for a new crop. This situation encourages the introduction of mechanised reapers. An equally just case exists for introducing wheat threshers, since the threshing of wheat in April-May, when both labour shortages and labour wages reach peak highs, impose a severe bottleneck for wheat farmers of Punjab and, indeed, of the whole of north India. Moreover, mechanisation is land-saving and is highly desirable in a land-scarce situation. Mechanisation also increases production substantially and eventually leads to profit maximisation - an element of rationalisation for the proft-minded, capitalist farmer. During the field studies, sufficient evidence was found to this effect. These big farmers are powerful advocates of the importance of mechanisation and oppose land ceiling and other reforms arguing that they are serious deterrents to agricultural production which is badly needed in a food-scarce situation.

Although there is no doubt that mechanisation has helped in increasing agricultural production and in reducing the foreign exchange food bill considerably, it has also created social, economic, organisational and political problems of wide dimensions. At a general level, lack of training in servicing and maintenance of tractors and other farm equipment is a severe handicap in the efficient use of machinery. The farmers are ignorant of the necessity of garaging, overhauling and maintaining their equipment. Most of them go for repairs only when the machinery stops functioning. Though government sponsored bodies are selling large proportions of tractors and other such equipment, they do not offer insurance for their proper running and servicing. The failure to provide regular servicing and maintenance of their equipment results in a considerably shortened lifespan for the equipment.

Repair and service facilities are also inadequate, inefficient, unreliable, expensive and time consuming. Most of the workshops, including government sponsored ones, are urban based, so that a farmer has to travel to these centres with his equipment and stay there until the work is finished. In addition to money costs, this results in lost time which he would have otherwise utilised on his farm. Government sponsored workshops are few and administrative bottlenecks further reduce their effective use and result in loss of confidence by the farmers. Often, the farmer prefers to go to a private workshop where the work is done in a reasonable time, though it will be expensive. Equally ineffective are the training courses, where they exist, simply because they are run by the universities, tractor-selling agencies and allied organisations, at district/university centres. Farmers, especially small ones, can ill afford to travel to these centres (though run free of charge) leaving their farms unattended for a month or so, especially when the new technology has created work for the year around.

On the contrary, a big farmer has all this to his advantage. He has the time, ability, resources and political influence to make full use of the existing facilities. He is not only making efficient and profitable use of the new technology on his own farm, but adding substantially to his profits by hiring out tractor, thresher, irrigation water and other such equipment to those who cannot afford to have their own. He also has, if necessary, the capacity of leasing land from others by offering higher rents knowing that he can account for them by producing more. As Myrdal (1970: 99) rightly comments, '...the difference between the best and the average is much wider in India...'. Consequently, the big farmer has always something to gain at the expense of the small farmer and landless labourer. This is leading to growing inequalities and is a matter of concern for the planner and politician alike.

iv) Labour and agriculture

The problem of creating employment has been and remains an integral part of the fair and equitable distribution of gains from the development processes, which in turn, have been, at least in theory, one of the key priorities of Indian planning. Looking back, however, labour has always been surplus in Indian agriculture. It is also recognised that a high proportion of Indian population (70 per cent) is engaged in agriculture compared with the technically advanced countries of the world. No doubt, the introduction of new inputs and adoption of new technology in the post-Independence agriculture, has created more opportunities for employment, but not on a scale which could absorb the increasing numbers of under-employed and unemployed. The question of unemployment is, therefore, a crucial one politically, socially and economically, and its resolution hinges upon the capacity of the new system to generate employment for the rural poor.

Punjab presents a sequence of some interesting developments of the post-Independence period which highlight some of the basic issues involved. It is with this aim that the employment issue is being investigated. Increasing irrigation facilities in the beginning, followed by the use of chemical fertilizers and the introduction of HYV seeds, created new dimensions in Punjab agriculture. This resulted in an increase in the intensity of cropping from 117 in 1950-51 to over 140 in 1970-71. Consequently, labour-shortages which are well known in Punjab, especially at peak periods, were aggravated. Another contributory factor, however, has been a reduction in migratory labour from Uttar Pradesh consequent to increased job opportunities in that State on which Punjab has always relied at these peak periods. Therefore, the need for labour-saving techniques was strongly felt and advocated for the first time in the early sixties. This followed the mechanisation of various farm operations. The introduction of tractors, power-operated tube-wells and pump-sets, and wheat-threshers soon became popular, which helped the farmers considerably over these labour shortages during the sixties. Though largely replacing bullock labour which is highly desirable in land-scarce situation, their impact on human labour was inevitable but largely counterbalanced by the new demand created by labour-intensive techniques of crop husbandry.

In the beginning, mechanisation was limited to essential farm operations and was introduced mainly to counterbalance labour shortages and to improve the efficiency of the farm production-mix. This balance was reversed in the late sixties. Rich farmers, due to their strong lobbying influence on the political decisions of the State governments, could manage to extend mechanisation to include the use of reapers, binders, harvesters, planters, threshers, transport trailers, and aerial spraying of crops by helicopters. This was labour-displacing simply because a pump-set requires 25 per cent of the man-hours required for a Persian wheel, a wheat-thresher 25 per cent of the man-hours needed by the indigenous method, a tractor 20 per cent of the man-hours entailed in bullock-drawn implements, a reaper 20 per cent of the man-hours needed by the indigenous method ... and so on (Billings and Singh, 1969). The demand for such equipment is increasing fast and it has been estimated that over 200,000 tractors, 100,000 planters (half driven by tractors and half by bullocks), 200,000 seed-cum-fertilizer drills (half tractor and half animal drawn), 200,000 disk harrows (bullock), 150,000 disk ploughs and harrows (tractor), 100,000 sprayers (power), 200,000 threshers/combines, 350,000 pumping-sets, and 200,000 trailers (tractors) will be in use by 1980 (Randhawa, 1974: 151). Though Punjab has been able to maintain a fair balance between demand and supply of labour during these years, a continuation of the present trend of mechanisation will surely lead to massive rural unemployment.

Another serious repercussion of the new technology has been a break away from the customary obligation which existed between the landowner and the agricultural labourer. The big farmers are becoming more commercially-oriented and individualistic in their attitudes. They are busy with their farms and farm improvements and exhibit limited interest in community life. On the contrary, they have a greater dependence upon the urban centres for their implements, their repairs and maintenance, and many other occupational and social requirements. Subsequently, the landowner is determined to convert all kind payment into cash and this process has been hastened by the rising prices for foodgrains in recent years. This is serious disadvantage to the labourer whose wages in kind have at least insured him a minimum food supply in the past. With the breaking away from the customary obligations, followed by new opportunities for employment in the urban centres, and increased and easy mobility, the village labour force tends to go in for non-farm employment in towns and cities.

v) Other improvements

Roads, railways, markets, storage, credit and finance, and research are essential ingredients in any development process, especially in the agricultural development of an underdeveloped economy. These provide the bases for and stimulus to economic growth. In a developing country like India, the role of the basic infra-structure is inevitably great and a well structured infra-structure is essentially a pre-requisite for the sustained stability of the development processes at work.

Roads are one of the most important linkages in the process of transformation of agriculture. These contribute significantly towards mobilization of resources and bring closer and reduce the gaps between rural and urban communities. Following the rapid development of agriculture in Punjab leading to substantial surpluses, it was imperative that the road network be improved since the scope for further expansion of existing rail transport was limited. Although there was considerable emphasis on improvements in road transport in Punjab in the post-Independence period, the main impetus followed the 'productivity breakthrough' in the late sixties. The use of new inputs added new dimensions to agricultural expansion so that the movement of input/output factors caused severe congestion on the existing network of roads. This was accentuated by the reduced time lapse between harvesting and marketing through the use of mechanical processing.

TABLE 17.4 METALLED AND UNMETALLED ROADS IN PUNJAB

(Road length in kms.)

Item	1960-61	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71
Metalled roads	5,384 (100)	6,370 (118.3)	6,668 (123.8)	6,923 (128.6)	8,095 (150.3)	10,043 (186.5)	12,111 (224.9)
Unmetalled roads	2,952 (100)	2,745 (93.0)	2,538 (86.0)	2,372 (79.7)	1,725 (58.4)	1,725 (58.4)	1,688 (57.2)
Total	8,336 (100)	9,115 (109.3)	9,206 (110.4)	9,295 (111.5)	9,820 (117.8)	11,768 (141.2)	13,799 (165.5)
Metalled roads per 100 sq. km. area	10.71	12.64	13.24	13.74	16.07	19.94	24.04
Unmetalled roads per 100 sq, km. area	5.87	5.45	5.04	4.71	3.42	3.42	3.35

Figures in parenthesis indicate index of increase 1960-61 = 100

Source: Chief Engineer, Public Works Department (Buildings and Roads), Punjab

In recognition of the situation and to give an additional fillip to agricultural activity in the State, the government launched in 1968-69 a Crash Programme of village roads at an estimated cost of Rs 174,000,000, out of which 25 per cent was to be contributed by the villagers in the form of land and voluntary labour. The concept of voluntary labour was well known due to the efforts of the Community Development Programme, yet the progress of rural link roads was slow and limited under this programme. Following the State government's commitment the response of the local population was immediate and overwhelming and 2,000 kilometres of new roads were added to the existing ones in 1969-70 (Table 17.4).

Consequent to these developments, rural accessibility to roads improved considerably in Punjab. For example in 1969, over 88 per cent of the villages and rural population were within 3 kilometres of a road (Table 17.5).

TABLE 17.5 RURAL ACCESSIBILITY TO ROADS IN PUNJAB, 1969

Details	Total	Within 1.6 kms.	1.6-3.2 kms.	3.2-4.8 kms.	4.8-6.4 kms.	6.4-8.0 kms.	Beyond 8.0 kms.
Inhabited villages	11,947 (100.00)	7,866 (65.84)	2,670 (22.35)	973 (8.17)	297 (0.98)	297 (0.98)	25 (0.20)
Rural population	8,567,763 (100.00)	5,698,417 (66.50)	1,850,555 (21.59)	690,264 (8.05)	214,536 (2.50)	91,545 (1.06)	22,546 (0.14)

Source: Mavi, 1970, cited in Randhawa, 1974: 157

Just over 3 per cent of the rural population and 2 per cent of the villages were located more than 5 kilometres from a road. The road accessibility map (Fig. 17.4) of Bist Doab clearly depicts the contrasts between the 1951 and 1971 situations. In 1951, large areas (almost half of Bist Doab) were beyond 5 kilometres from a road, whereas in 1971 it was only limited to a few isolated patches in the eastern hilly parts. Moreover, the condition of the roads has also improved considerably during this period and are being maintained properly. Most of the roads handle two-way traffic.

Markets and storage facilities are equally essential components of agricultural development in an expanding economy. Although these were always reasonably developed in Punjab, yet they were both inadequate and inefficient for coping with the new additional requirements created by the HYVP which resulted in unprecedented large marketable food-grain surpluses. The State government tackled the emerging situation to a large extent in two ways: i) by making provision for new additional markets, and ii) by expanding and improving the existing regulated markets. Subsequently, the number of regulated markets increased from 87 in 1966-67 to 91 in 1970-71, and the number of sub-yards attached to these markets from 154 to 162 during the same period. Simultaneously, the handling capacity of the markets was improved. Most markets now have concrete floors opposed to the conventional mud floors and hand balances have been entirely replaced by heavy duty spring balances with a consequent improvement in the efficiency of marketing. Grading of foodgrains has also been introduced and this provides an additional impetus to the farmer to improve the quality of his crop.

With increasing production and procurement of foodgrains, the need for more extensive storage facilities was inevitable. A Crash Programme for the additional construction of 100,000 tonnes storage capacity to the existing 31,656 tonnes (1966-67) was begun in 1968. By March 1972, the total State-owned storage capacity had grown up to 120,656 tonnes, largely in the form of binns and godowns (Table 17.6). During 1971-72, the record procurement of wheat (2,938,000 tonnes) in Punjab created an acute storage problem. The State

TABLE 17.6 STATE-OWNED STORAGE CAPACITY IN PUNJAB, 1972

(in tonnes)

District	Bins	Godowns	Sheds	Khatties	Shops/ rooms	Total	Percentage to total
Amritsar	-	4,000	-	-	-	4,000	3.3
Hoshiarpur	-	2,000	-	-	770	2,770	2.3
Jullundur	-	1,000	-	-	1,450	2,450	2.0
Ludhiana	10,000	14,140	1,000	-	-	25,140	20.8
Ferozepur	9,000	6,700	2,000	-	-	17,700	14.7
Gurdaspur	2,164	-	-	-	-	2,164	1.8
Patiala	4,000	9,800	-	1,600	-	15,400	12.8
Sangrur	14,000	11,000	-	800	-	25,800	21.4
Bhatinda	14,000	5,000	732	4,500	-	24,232	20.1
Kapurthala	1,000	-	-	-	-	1,000	0.8
Ropar	-	-	-	-	-	-	-
Total	54,164	53,640	3,732	6,900	2,220	120,656	100.0
Percentage	44.9	44.5	3.1	5.7	1.8	100.0	

Source: Government of Punjab, Economic and Statistical Organisation, Publication No. 170, 1972

government had to rent accommodation to the extent of 465,000 tonnes for storage. In addition, 3,889 tarpaulins and 32,000 crates were provided to protect the stocks lying in the open from inclement weather. The Punjab State Supplies and Marketing Federation has completed godowns to take 200,000 tonnes and work on the construction of godowns for 100,000 tonnes is in progress. The Food Corporation of India has a storage capacity of 694,980 tonnes in 1971, while godowns to hold a further 239,745 tonnes are under construction. The Punjab State Warehousing Corporation can store 16,500 tonnes. It has also initiated a Crash Programme to construct godowns with a total capacity of 266,000 tonnes.

At the village level, however, the producer himself continues to be the storing agency, largely using conventional methods. A considerable proportion of the farmers, however, have started using jute bags for storage, while some rich farmers are using metal bins - 10,000 of them have been introduced in the State.

The problem of storage continues to be serious. Any loss of foodgrains through lack of proper storage or other administrative difficulties is highly undesirable in a food-scarce situation. The need for proper storage facilities is very great not only to cope with the increasing agricultural production but also for building up buffer stocks.

Farm credit and finance remain crucial issues in the adoption of High-cost-High-yield technology in a capital-scarce economy. Historically, Indian peasants have always been in debt and the money-lender has been the major source of credit. It may be noted that the money-lenders are largely the village business men or big landlords. In the early fifties, for instance, the money-lender provided about 70 per cent of the total rural borrowings. Despite high interest rates, ranging between 12-33 per cent per annum, the money-lender remains an indispensable source of credit to the bulk of the farmers. If for no other reasons than easy accessibility, simple and elastic terms of credit, personal contact, local knowledge and experience as opposed to the time-consuming and cumbersome process to avail credit facilities and the inadequate funds made available by the government and other co-operative agencies. Nonetheless, his share of credit has been eroded considerably with the rise of institutional credit agencies during the period under review.

Although cooperative credit was instituted as early as 1904 (The Cooperative Credit Societies Act - 1904), its role has been very limited and performance uneven. Most of the cooperatives were too small to be viable. In response to various developments in the post-Independence period, however, there emerged a wide recognition of the critical importance of farm credit and subsequently a more pragmatic approach was evident. This gained an additional momentum in the wake of introduction of seed-fertilizer-pesticide-irrigation technology in the late sixties. Consequently, many structural and procedural changes became evident. Small Credit Cooperatives were reorganised to form large Service Cooperatives with enlarged functions including the supply of various agricultural inputs. The criterion for the eligibility of various loans were relaxed, and for the first time, the advance of loans was linked with crop production. The recoveries were allowed to be made from the proceeds of the sale of crops. A Crop Loan Scheme was also introduced in 1967.

Following these qualitative changes, there has been a substantial quantitative expansion in the credit facilities. A major stimulus to credit expansion came in 1967-68 when the Punjab government contributed a large subscription to the share capital of the Central Cooperative Banks. This followed the support of the Reserve Bank of India to the Land Bank Structure as well as the central government's budgetary support. The result was that while the number of Primary Agricultural Credit/Service Societies increased slightly from 10,604 in 1966-67 to 10,932 in 1970-71, the working capital of these societies doubled from Rs 357,400,000 to Rs 765,000,000 during the same period. The number of Agricultural Marketing Societies also grew in number from 105 in 1966-67 to 114 in 1970-71 while their working capital increased more than three-fold from Rs 41,000,000 to Rs 151,400,000. Subsequently, there

TABLE 17.7 LOANS ADVANCED BY GOVERNMENT FOR MINOR IRRIGATION WORKS

(in lakhs Rs)

Item	1960-61	1965-66	1966-67	1968-69	1969-70	1970-71
1. Wells	7.99	12.17	18.42	10.10	9.00	1.90
2. Tube-wells	3.75	54.49	68.99	86.05		
3. Pumping sets	3.15	41.97	84.14	57.57	89.90	22.30
Total	14.89	108.63	171.55	153.72	98.00	24.20

Source: Director of Agriculture, Punjab, cited in Government of Punjab, Economic and Statistical Organisation, Publication No. 170, 1972

have been progressive increases in the amount of loans advanced by the government and other agencies (Tables 17.7 and 17.8). The amount of loan advanced under the Crop Loan Scheme was Rs 619,667,000 in 1968-69, Rs 528,144,000 in 1969-70, and Rs 572,659,000 in 1970-71. Of the total loans advanced in 1970-71, 93 per cent was short term loan for meeting current agricultural needs and the remaining 7 per cent medium term loans. About 54 per cent of these loans were provided in kind in the form of improved seeds, fertilizers, and pesticides.

Although these improvements seem substantial, they provide only partial solution to the serious issue of farm credit. Undoubtedly much of the impetus of the new developments has apparently been supported by private resources available to farmers. On the one hand big farmers with sufficient resources of their own , multiplied them further by obtaining loans and subsidies from the government and other allied agencies. They indeed, made full use of the credit facilities largely because they had the means, the ability and the power to ensure that the resources are steered their way. On the other, the small

TABLE 17.8 LONG TERM LOAN ADVANCED BY PRIMARY LAND MORTGAGE BANKS IN PUNJAB

(in lakh rupees)

Purpose of loan.	1968-69		1969-70		1970-71	
	Amount	Percentage	Amount	Percentage	Amount	Percentage
1. Debt redemption	10.19	0.77	29.64	1.66	50.33	2.57
2. Purchase of land	7.71	0.58	13.61	0.76	42.09	2.15
3. Purchase of tractors	358.38	26.95	610.06	34.09	699.97	35.78
4. Installation of tube-wells	877.31	65.97	944.88	52.81	1,000.03	51.11
5. Other land improvements	76.17	5.73	191.10	10.68	164.19	8.39
Total	1,329.76	100.00	1,789.29	100.00	1,956.61	100.00

Source: Registrar, Co-operative Societies, Punjab, cited in Government of Punjab, Economic and Statistical Organisation, Publication No. 170, 1972

farmer had certain obvious disadvantages such as his limited credit absorption capacity, administrative and procedural forces opposing him (despite the relaxation of eligibility rules) and his higher vulnerability to risks. The enormous requirements for farm credit generated by the High-cost-High-yield technology seems to be beyond the capacity of the present system. The institutional organisation of the farm credit structure will only be tested fully when the new technology spreads to the less affluent, small farmer who form the bulk of the peasantry of Punjab or for that matter of India.

Research and extension The need for agricultural research and extension was realised as early as 1904, when the Indian Agricultural Research Institute (IARI) at Pusa was established. A year later, the framework of agricultural administration was set up by establishing an Indian Agricultural Service, as a centralised cadre. This was followed by the establishment of the Indian Council of Agricultural Research (ICAR) in 1929. The work of teaching, research and extension in Punjab as in other States was largely carried out by the State Department of Agriculture. It had a three-tiered structure: Deputy Director at the State level, District Agricultural Officer at the district level, and Agricultural Inspector at the base. Despite these developments, the pace of research was slow and achievements were limited. In British Punjab, however, some improved wheat varieties such as C518, C519, C228, C217 and C250 were evolved at the Agricultural College, Lyallpur (now in Pakistan). The introduction of these varieties helped considerably in increasing wheat production in the thirties and forties. But these arrangements were not only inadequately modest, but the links between research and extension were weak and often ineffective. Nevertheless, these institutions provided the basis for the marked research expansion in the post-Independence period.

The period under review has seen unprecedented achievements, both qualitative and quantitative, in research and extension, although uneven in direction and emphasis. In addition to the Five-Year Plans, other major programmes introduced were:

Community Development Programme (CD)	1951-52
National Extension Service Programme (NES)	1952-53
Panchayat Raj	1960-61
Intensive Agricultural District Programme (IADP)	1960-61

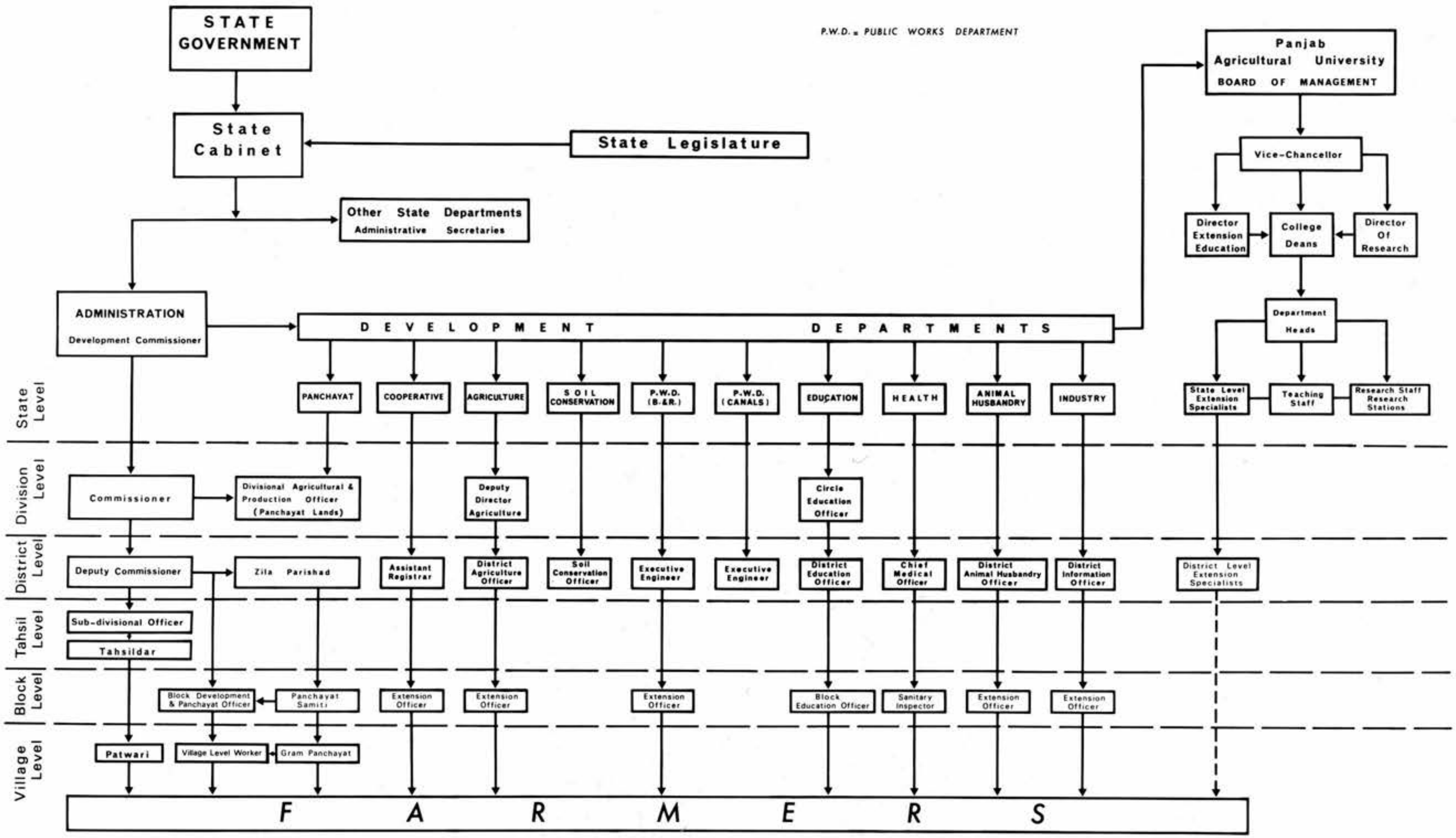
Intensive Agricultural Area Programme (IAAP)	1964-65
High-Yielding Varieties Programme (HYVP)	1965-66
Multiple-Cropping Programme	1967-68
National Commission on Agriculture	1969-70

(For details, see Chapter 18)

Consequent to these developments, a whole range of facilities for teaching, research and extension are provided by the various departments and Research Institutes (Table 17.9). Although most of the work is co-ordinated through various State departments, the major extension and development work is carried out through the Block Development machinery i.e. the B.D.P.O.s and village level workers (VLW). At present, the whole of Punjab is covered by 116 Blocks, each block covering 110 villages on the average. The Punjab Agricultural University, Ludhiana is the major research and teaching Institute. It also runs 4 Regional Research Stations, 4 Regional Research Sub-stations and 1 Nucleus Seed Production Farm. The university holds two farmers' fairs every year - one before the sowing of summer crops and the other before the sowing of winter crops. Such fairs are also organised by the B.D.P.O.s at Block levels. The contribution of Punjab Agricultural University in research has been substantial, not least being the development of various crop varieties (Table 17.10) which have helped the State to increase agricultural production substantially.

At the national level, ICAR is now a major co-ordinator of research and extension throughout the country. After reorganisation in 1965 it now has 25 Research Institutes and 8 Soil Conservation and Training Centres under its control. In addition, there are 12 Agricultural Universities, 73 Agricultural Colleges and 20 Veterinary Colleges in the country. In the field

TABLE 17.9 AGRICULTURAL ADMINISTRATION, RESEARCH AND EXTENSION HIERARCHY OF PUNJAB



of research, the Rockefeller Foundation through its co-ordinated research programmes, has contributed substantially to the present promise of HYVP. These efforts are being augmented by the research programmes conducted by IARI at the centre and various research stations in the States.

Despite various discrepancies in research and extension, the overall record of accomplishment has been great. In the initial stages, efforts were largely directed towards increasing production but much remained to be done especially in areas of soil and water management and pest control. A change in emphasis, therefore, was necessary and was eventually provided. Today the emphasis is on adaptive research, combining the high-yielding varieties of exotic and some Indian varieties of seed with the still desirable qualities of drought and disease resistance. However, the work of research and extension was a less critical handicap in the early stages of the new move forward in agriculture, than it will be in the future. The problem is not now of any lack of sense of need and purpose, or lack of scholarship, but whether adequate funds will be provided to support research organisation. This may prove far more critical in the years to come.

CONCLUSIONS

The modernisation of Punjab agriculture has occurred in response to many developments in the post-Independence period. Despite various law evasions, the impact of land reform measures has been considerable though uneven in direction, time and emphasis. The occupancy tenants were given proprietory rights while absentee landlordism declined substantially. Consequently, four fifths of the cultivated acreage is now cultivated by the owners, and the remaining one fifth by tenants (1969-70). Above all, there was infused a new spirit of dignity and prestige among the rural masses. The

TABLE 17.10 NEW CROP VARIETIES EVOLVED AND RELEASED BY P.A.U.

S. No.	Name of crop	Margin of superiority to the standard	Year of release
1.	Bajra		
	S. 530	5%	1965
	H.B. No. 1	60% to 100%	1966
2.	Cotton		
	J. 34 (American cotton)	25%	1966
	G. 27 (indigenous cotton)	25%	1969
3.	Fodder		
	N.B. 21	30%	1970
4.	Maize		
	Vijay	37%	1969
5.	Oilseeds		
	Groundnut C 145	20%	1968
	Castor No. 1	30%	1965
	Yellow Sarson Pb. 24	20%	1966
	B.S.H. No. 1	21% to 37%	1966
	Til Pb. No. 1 (Sesame)	25%	1966
	Linseed Lc 185	26%	1970
6.	Rice		
	Norin 18	25%	1967
	IR 8	40%	1968
	Jhona 351	34%	1968
	Jaya	21.8%	1971
7.	Sugarcane		
	CO 1148	15%	1967
	CO 67-11	26%	1968
	CO J. 58	36%	1970
	CO 1158	12%	1970
	CO 975	15%	1970
8.	Wheat		
	C 306	17%	1965
	PV 18	60% to 90%	1966
	Kalyan-Sona 227	30% to 100%	1967
	S 308	45% to 90%	1968
9.	Guara		
	227	43%	1971
10.	Moong		
	G 65	51% to 61%	1971
11.	Soyabean		
	Bragg	28.7%	1971
12.	Tobacco		
	C 302	29%	1965
13.	Tomato		
	S 12	70%	1967
14.	Musk-melon		
	Hara Madhu	43%	1967

Source: Randhawa, 1974: 75

timely completion of the consolidation of holdings (1966-67) has been an additional impetus in improving the agricultural production-mix through the adoption of the seed-fertilizer-irrigation technology.

The rapid adoption of seed-fertilizer-irrigation technology by the farmers resulted in substantial increases in farm production and in diversifying the production patterns. Wheat has been a success story par excellence, while the performance of hybrid maize, rice and bajra has been moderate. The application of chemical fertilizers has increased substantially, though the quantities used have been much smaller than those recommended. The use of pesticides, however, remained largely curative rather than preventative. Mechanisation of farm operations has been rapid, though it has occurred in response to changes in the demand for farm energy relative to increased farm production. The new technology, no doubt, has been responsible for increased production, but it has also aggravated the already inequitable distribution of wealth and income among the rural population.

Faced by rapid productive changes, the whole structure of government, co-operatives and other institutions has been forced to change. Substantial increases in farm credit and finance, favourable prices and adequate supplies of inputs, improved rural accessibility, expanded market and storage facilities, guaranteed minimum price-structure of foodgrains, and other services and incentives have also contributed to increases in farm production and employment. Research, teaching and extension facilities have also improved considerably during the period under review, though largely directed towards production increases. There have been, however, gaps in efforts towards soil and water conservation and management.

These developments have several important implications for the future, as well as for the present. Higher investment in farm machinery, HYV seeds, chemical fertilizers and pesticides involve the creation and control of major production and distributive organisations, and much increased standardisation, quality control and a whole new industry for the repair and maintenance of equipment. The long-run effects of farm mechanisation reducing farm employment are inevitable and the continuing trend could lead to massive unemployment. Furthermore, the government's efforts to ensure fair access by the smaller and less affluent farmer to supply and credit institutions and to avoid the widening gap between rich capitalist farmer and the poor peasant which a new technology tends to cause automatically, present it with a difficult task and call for a new set of special agencies to handle the necessary programmes. But in the words of Ladejinsky (1970: 766) 'The current emphasis is on productivity, to the exclusion of social imperatives: the first will bring India to self-sufficiency; the second is beginning to yield great vexations'.

CONCLUSIONS

CHAPTER 18

CONCLUSIONS

This study set out to test the hypothesis that agricultural development is a process of 'linked stages' in which the introduction of the first prepares the necessary grounds for the next. It was also aimed to define the method of linkages and to isolate in a northern India context the critical factors involved in agricultural change. These were hypothesized to be water and the human element. While identifying and analysing the changes which occurred during the period under review, a sequence of events has been established. It was observed that a variety of programmes/plans were introduced at different time periods which provided the essential linkages, structures and institutions to initiate, promote, complement and sustain agricultural growth in Punjab.

There exist a large variety of theories of economic development, but they were exclusively conceptualised and devised in the environments of the developed economies of the world (see the detailed bibliographic review by Keeble, 1967). Most of these theories deal with growth as an ongoing process, while others identify successive stages in rates of growth and in the structure of the economy. The 'stage theories' are derived from economic history and postulate that the growth of an economy follows a fairly uniform pattern of successive stages. While none of these theories *per se* can satisfactorily be applied to the developing economies, nevertheless they illuminate the sequence of occurrences taking place therein, and provide a foundation for model-building. A brief review of some of these theories therefore, may be useful at this point.

The earliest 'stage theories' were expounded by various German economists in the nineteenth century, particularly Friedrich List, Bruno Hildebrand, Karl Bücher, Gustav Schmoller and Werner Sombart. These were subsequently refuted as mere descriptive classificatory exercises and of little use as analytical tools. A thoroughly worked out theory and the one which has excited great interest and controversy has been put forth by Rostow. Rostow's five stage theory 'A Non-Communist Manifesto' was designed as '... an alternative to Karl Marx's theory of modern history...' dramatizing '... not merely the uniformities in the sequence of modernisation but also - and equally - the uniqueness of each nation's experience' (Rostow, 1960: 1-2). Rostow's theory indeed has stimulated an enormous amount of research into economic growth models. At the same time it has provoked lively criticism, notably that

(i) the successive stages are largely unidentified, so that they remain unidentifiable by reference to verifiable criteria;

(ii) it fails to specify any mechanism of linking successive stages;

(iii) the stages cannot be separated and therefore are often complementary and overlapping;

(iv) it does not account for the interaction of the variables introduced at each successive stage.

A full review and criticism has been provided by Cairncross (1962).

In contrast to the rigid stage theory of Rostow, Johnston and Mellor (1961) proposed a three-phase theory of agricultural development which seems more valid in the developing countries. The three phases are

(i) preconditions; (ii) labour-using, capital-saving techniques; and finally, (iii) capital-using, labour-saving improvements. The preconditions phase includes the break-up of the traditional pattern of rural life, programmes of land reform, awareness by producers of opportunites and benefits of change, and mobility and flexibility resulting from participation in the market. In the second phase, programmes are introduced for the advancement of education to improve scientific understanding, the development of better seeds and breeds, better cultivation and crop protection methods, the application of chemical fertilizers, better roads and marketing provisions, and rural access to credit and finance. Finally, in the third phase of development, large-scale water control schemes are implemented and mechanisation of farm operations is introduced.

A more realistic approach to agricultural development of the developing countries lies in a general theory of 'efficient sequences' put forth by Hirschman (1958). The theory as restated by Hunter (1969: 114-115) is that growth is '... essentially a process of linked stages, in which one step so alters the situation that a second step becomes both desirable and possible; and the second step points to and facilitates a third. ...with the proviso that each must be genuinely linked to the one before'. In other words, agricultural change is a continuous process; stages are artificial divisions. Indeed the change occurs

> ... as a long chain of small, related sequences, each of which determines the possibilities for the next. Like flood-water spreading on uneven ground, the runnels of change divide and coalesce again, here are diverted by a hillock, there are checked in a depression, build up, and break out again in new directions. The history of man in society can give some helpful indications of its general course; its detail is a matter of exact and patiently accumulated knowledge of the social topography of each special case.
>
> (Hunter, 1969: 293)

With the passage of time, the development process grows to its broadest dimensions. There are, however, some major breakthroughs in the course of this process which provide the catalyst or big 'push' needed to get the process of economic development moving. These 'push' factors constitute powerful and valuable levers for development which must be carefully operated and maintained to help start a 'chain reaction' leading to sustained growth. In the discussion to follow, these 'push' factors are identified and the course of 'efficient sequence' is established.

PROCESSES OF CHANGE

There is ample evidence of adaptation and change in Punjab agriculture. These reflect the exogenous and endogenous forces influencing farming at different times, in response to which, farmers have continually altered their techniques of farming and the proportion of land allocated to different crops. The sequence of these forces has been significant in development.

Initiation of the process

The process of agricultural change in Punjab, or for that matter India, has its roots as far back as the Colonization Schemes introduced during the British Period in response to food shortages being experienced in the country at that time. In Punjab, although the first two canal colonies, Sohag-Para and Sidhani, (both now in Pakistan) were started as early as 1886-88, the major breakthrough came with the establishment of the larger Canal Colonies of the first quarter of the twentieth century. The establishment of Canal Colonies had two objectives: (i) to relieve population pressure in the congested parts of the Central Punjab; and (ii) to increase food production to meet the increasing demands of the growing population. The colonists came largely from the farming communities of the Central Punjab and most of them were peasant proprietors, for example, peasants accounted for '... about 80 per cent of the land in the Lower Chenab (Lyallpur) Colony' (Farmer, 1974: 22). These Canal Colonies were

> ... the classic achievement of the British administration in the Punjab, where colonization was indeed on the grand scale. For the Punjab Canal Colonies eventually covered 2.2 million hectares of land, almost all of which had been previously waste or subject only to nomadic pastoralism or occasional catch-cropping. Nothing on the same vast scale has so far been achieved in independent India, ... It was, of course, the construction of great irrigation channels that enabled the colonists to bring the previously arid or at any rate semi-arid *doabs* of the Punjab under plough.
>
> ... they [the Canal Colonies] formed the greatest achievement in colonization ...; and that they were in various ways the model and the inspiration for schemes of colonization, past and present, in the present territory of the Indian Republic.
>
> (Farmer, 1974: 19-20)

These colonies clearly demonstrated that given the will and skill of the people involved, the so-called 'vicious circle' of tradition and backwardness can be broken. The local nomadic inhabitants who were opposed to any change in their traditional way of life, and who were very hostile to the new settlers in the beginning, were finally convinced of the benefits of the new economy and were converted 'from a lawless nomad into an industrious agriculturalist' (Darling, 1947: 123). For the colonists who came from the Central Punjab, these colonies provided a training ground for the adoption of irrigated farming, improved seeds, implements and cultural practices, while for the planners and researchers, they were testing grounds for the modernization of agriculture.

To promote research and extension, the establishment of the Indian Agricultural Research Institute in 1904, the Indian Agriculture Service in

1905, and the Indian Council of Agricultural Research in 1929, were highly commendable steps at the time. Other programmes included the enactment of The Co-operative Credit Societies Act - 1904, and consolidation of holdings through Co-operative Consolidation Societies in 1920. The 'Grow More Food' campaign launched during the Second World War received an additional fillip during the Bengal Famine of 1943. Although these programmes had a very limited impact on the total economy at that time, they helped in educating the people about the need and urgency of the improvements as well as providing the foundations for the development of the institutional and structural framework of the post-Independence network of research, extension, education and credit. Indeed, the general impetus of these was carried forward into the post-Independence period.

With Independence came mass exodus; Muslims towards the west and non-Muslims to the east.

> Uprooted from all moorings, robbed of the most elementary belongings, deprived of many a member in each family kidnapped or killed in cold blood, the new citizens of India - five million of them from West Pakistan ... had to be found shelter, food and medical relief at once and then a permanent place where they could be absorbed gainfully.
>
> (Dey, 1969: 4)

To execute this huge task of rehabilitation of the refugees, the new Ministry of Relief and Rehabilitation came into existence overnight. Later, a new Board called the Rehabilitation and Development Board was created and attached to the Ministry. The bulk of the work in Punjab was successfully completed within five years, while the remaining work was carried out through the First Five-Year Plan. Thus the first five years of Independence (1947-1951) mark the transitional period when the old efforts were consolidated and new thinking cystallized. Within this period, the government of India decided that drastic economic changes were essential for survival. It also decided to design and implement programmes for planned economic development within a socialist society.

Extension of agriculture and diffusion of irrigated farming (1951-61)

The period of planned development began with the initiation of the first Five-Year Plan in April, 1951. The First Plan (1951-56) sought to rehabilitate the economy from the disruptions of the Partition and to build a base for a developing economy. Subsequently, Punjab government introduced various measures to improve agricultural production in the State. These largely included land tenure reforms, a ceiling on land holdings, consolidation of holdings, provision of regulated markets, farm credit and finance, and the building up of various development agencies.

The Community Development Programme was the first of its kind and was launched in Punjab, as in the rest of India, on October 2, 1952. This was followed by the National Extension Programme a year later. Both of these, in fact, are related phases of the same programme, the former being described as the method and the latter as the agency through which transformation of social and economic life of villages was to be initiated. The main objectives were to provide the initial stimulus, to establish a method of co-ordinated working between various agencies, and to build up people's organisations for rural change. These were aided self-help programmes, planned and implemented by the villagers with government technical guidance and financial assistance. The major concern was the expansion of agricultural production and the growth of subsidiary occupations which were the necessary foundations for the development of social welfare services in rural areas.

The new strategy of agricultural development was carried through by creating a new development unit called a 'development block'. From a humble start, the entire State was divided into 116 development blocks by 1960-61; each block comprising about 110 villages with a population ranging between 60,000 to 100,000. A Block Development and Panchayat Officer (B.D.P.O.) co-ordinates the activities of the officials of the various departments involved in rural development at block level, while 10 Village Level Workers (V.L.W.) provide a direct link between the farmers and the development officials (a complete hierarchy is shown on Table 17.9). The process of agricultural expansion received additional support from the increased farm credit and finance institutions. The co-operative structure introduced during the British period was reinforced in September 1954 with the formation of The Punjab State Co-operative Supply and Marketing Federation Ltd., generally known as 'Markfed'. Its main objective was to provide an integrated structure of marketing of farm production and supply of farm inputs.

Efforts to improve agricultural production during the first Five-Year Plan were concentrated on building up the institutional framework and rehabilitating the refugees from West Punjab (Pakistan), and consequently increases in agricultural production remained marginal. The Second Five-Year Plan (1956-61) sought to extend the process by taking a fresh look at the whole background and by attempting to make up for any deficiencies. During this plan, the coverage of the Community Development Blocks was extended and their administrative structure was further strengthened. In September, 1956, a new Ministry of Community Development at the national level was created to give further impetus to the community development concept. To encourage participation by farmers in the planning and developmental processes, a three-tiered programme of Panchayats was initiated in Punjab, as in some other States, in 1961. Consequently, the existing Panchayat system was reorganised to form elected bodies at the village, block and district levels (Table 17.9).

The most important linkage in the early stages of these development processes was indeed provided by the 'refugee farmers' who migrated from the canal colonies of West Punjab (Pakistan) and were settled in Punjab. These farmers had a long experience of irrigated farming and were more progressive than their local counterparts. As soon as land was allotted to them, they started digging individual wells and installing tube-wells for irrigation. They acted in three ways: (i) by accepting the innovations being propagated by the Development agencies, (ii) by diffusing irrigated farm practices and techniques, and finally (iii) by reclaiming new lands. This may be considered a 'relocation diffusion' process which emerged largely as an historical accident and although not recognised at the time, this proved to be the most significant development of the period. The combination of these factors boosted the agricultural economy of the State so that Punjab registered an increase of 76.5 per cent in agricultural production as compared with an all India figure of 46.4 per cent during the first two Five-Year Plan (1951-61) periods. However, the strategy for increasing agricultural production largely remained acreage-dominated rather than yield-dominated.

<u>Period of induced agricultural change (1961-66)</u>

The Third Five-Year Plan (1961-66) marks the beginning of induced agricultural change. Having realised the inadequacy of the Community Development Programmes in achieving the desired results, a new extension approach 'Intensive Agricultural District Programme' based on the recommendations of a Ford Foundation team of specialists, was launched in the country in 1961. The scheme was adopted in nine, later extended to sixteen, districts of various States, which were selected on the basis of greatest potential for agricultural improvement. In Punjab, Ludhiana district was selected, although 'in terms of its propensity to alter land use patterns in response to technological change, it came eleventh out of the districts of the Punjab' (Harriss, 1972: 88). In practice, circumstances combined to favour Ludhiana giving the necessary lead and essential initiatives required to generate agricultural change in Punjab. Today Ludhiana emerges as the most progressive district of Punjab. In the words of Johnson (1971: 174) 'If Punjab is the cream of India, Ludhiana district in the Punjab is the cream of cream'. The emphasis was on a package of improved practices which included the increased use of fertilizers, improved seeds, pesticides, new implements and increased credit facilities. Special emphasis was placed on strengthening institutions necessary to provide adequate and timely supply of farm inputs to the farmers. An additional Pilot Project Officer was appointed to co-ordinate the work at district level.

Another important feature of this period was the establishment of Punjab Agricultural University at Ludhiana. This provided a sound base for agricultural teaching, research and extension in the State. At the same time, six subject matter specialists in agronomy, horticulture, plant protection, soil science, farm management and animal husbandry were appointed at district level in the State. Their main function was to promote new innovations and to advise the farmers and other field staff in day to day developments. Complementary to I.A.D.P., another programme 'Intensive Agricultural Area Programme' was introduced in 1964-65. This programme concentrated on specific crops but with a reduced extension staff. The success achieved through these programmes, coupled with the will of the government to introduce new innovations and the ready willingness of the farmers to accept them, resulted in increasing use of fertilizers, pesticides, new seeds and implements. Mechanised, self-controlled and assured supply of irrigation water through the use of power-operated pump-sets and tube-wells greatly changed the face of Punjab agriculture. The creation of the Agricultural Price Commission in 1965 highlighted the need for more rational price policies. During this period, increasing efforts were made in the much ignored subjects of soil conservation and water management.

A major transformation of agriculture occurred through the implementation of these programmes and agricultural production increased substantially (Table 18.1).

TABLE 18.1 AVERAGE AGRICULTURAL PRODUCTION IN PLAN PERIODS IN PUNJAB

	First Plan	Second Plan	Third Plan	1971-72
Foodgrains (tonnes)	1,980,000	2,291,000	3,162,000	7,850,000
Sugarcane: Gur (tonnes)	257,000	270,000	486,000	500,000
Cotton (bales)	247,000	433,000	669,000	967,000
Oilseeds (tonnes)	72,000	70,000	121,000	360,000

Source: Department of Agriculture, Punjab

The period of induced agricultural change brought into focus various elements of the evolving agricultural strategies for the ensuing periods. These included the interaction of various improved agricultural practices as a package, the time-saving techniques in response to increasing labour requirements due to multiple cropping, increased demand for better roads, markets, storage and other related facilities.

A breakthrough (1966 onwards)

A real breakthrough in Punjab's agriculture and, for that matter, in India's agriculture, came with the introduction of the High-Yielding Varieties (HYV) Package in 1966-67. This came at a time when the agricultural base of Punjab was very well founded in many ways. The process of consolidation of holdings was completed in 1966-67 giving farmers compact farm holdings together with access roads. The consolidated farms, coupled with the availability of new power sources and increased farm credit, provided a timely opportunity to the farmers to install tube-wells and pumping-sets for the self-controlled and assured supply of water necessary for the successful adoption of HYV package. Most of the irrigation projects, including the Bhakra Nangal multi-purpose project, initiated in the earlier periods were fully operative in the State and as a result over 65 per cent of the total cropped area was under irrigation in 1966-67. This figure increased to 75 per cent by 1970-71. Moreover, Punjab Agricultural University had considerable success in evolving new varieties of seeds (Table 17.10) which further accelerated the development process in the State. Indeed, the Punjabi farmers were fully equipped to adopt the innovations which the government and other allied agencies were pushing through with great vigour and enthusiasm, while elsewhere the process of development was very slow.

The drought years of 1965-66 and 1966-67 rocked Indian agriculture severely, although the effect in Punjab had been very small, for a good irrigation base helped considerably to cushion the adverse effects. The impact of these drought years on the national economy was so great that it led to increased emphasis upon policies and programmes to accelerate the expansion of agricultural output and simultaneously to build the necessary infrastructure to boost the agricultural economy with particular stress on irrigation facilities. The changes in government policies and programmes are evidenced in the budgetary allocations, specifically in foreign exchange allocations, and the annual plans for 1967-68 and 1968-69 accorded the highest priority to agricultural production and other related programmes including an adequate and timely supply of farm inputs. In April, 1969, the Planning Commission reintroduced five year planning and the fourth Five-Year Plan (1969-74) was launched with twin objectives: (i) to provide conditions necessary for a sustained production increase of 5 per cent per annum, and (ii) to enable as large a section of the rural population as possible to participate in development and share its benefits.

Other programmes included the minimum procurement price for grains after 1966, the establishment of Punjab State Agro-Industries, the activation of the 'Markfed', the reinforcement of the Department of Agriculture, crash programmes for link roads, storage and marketing, introduction of multiple-cropping programme, and soil conservation and water management programmes. Though these programmes helped the State to increase its agricultural production considerably, it created at the same time large gaps between the big and the average farmer. The social imperatives to reduce this gap led the government of India to establish in 1971, the Small Farmers Development Agency (S.F.D.A.) and the Marginal Farmers and Agricultural Labourers Agency (M.F.A.L.) to help small and marginal farmers. These have been operating in Punjab since then. Another important decision taken by the government of India was to establish a National Commission on Agriculture in September 1970. The object of this commission is to make a comprehensive review of the Indian agriculture and recommend programmes and policies for its faster growth.

Most of the programmes of this period, were in fact expressions of new emerging needs as well as a response to existing demands. After the initial success of various programmes, their continuation, extension and reinforcement was critical and led to developments such as the increasing role of 'Markfed' and 'Agro-Industries' corporation of Punjab. Most of the farm inputs were channelled through the farmers' co-operatives. Mechanisation and automation of farm operation increased considerably, and specialised farm implements and machines were introduced to overcome some of the obvious difficulties. These included reapers, binders, groundnut harvesters, planters and so on (Table 17.3). Subsequently, the network for the flow of information, ideas and new innovations was extended to cope with these new requirements. An important feature of this period has been the emergence of precise and specific policies in response to specific problems of agriculture. Whether or not these programmes will generate the essential dynamics to achieve the desired results, only time will tell.

This period experienced a form of 'chain reaction' through the execution and persistent continuation of various programmes and policies in operation since Independence. As a result, achievements have been very substantial. The acreage under HYV, particularly wheat and rice, increased considerably (Fig. 17.2) leading to record productions. For example, wheat production increased from 1,916,000 tonnes in 1965-66 to 5,600,000 tonnes in 1971-72; rice production increased from 292,000 tonnes to 919,000 tonnes during the same period. Moreover, this increased production exceeded the procurement targets during 1970-71 and 1971-72 (Table 18.2).

These increases were possible only when the Punjabi farmers participated fully in the development processes. It may be pointed out here

TABLE 18.2 PROCUREMENT OF WHEAT IN PUNJAB (000 tonnes)

Name of agency	1970-71 Target	1970-71 Procured	1971-72 Target	1971-72 Procured	1972-73 Target
State Food Department	1,000	995	1,250	1,250	1,400
Marketing Federation	700	706	725	897	1,000
Food Corporation of India	700	674	725	791	1,000
Total	2,400	2,375	2,700	2,938	3,400

Source: State Food and Supplies Department, Punjab

that it was again the leadership of the refugee farmers, who willingly accepted the new innovations, which made Punjab a forerunner in the process of 'take-off'. Equally important has been the role played by local '*Ramgarhias*' in designing and inventing various agricultural implements including chaff-cutters, threshers, sprayers, seed-cum-fertilizer drills, mouldboard ploughs and various others. They were also pioneers in industry and the manufacture of electric motors, diesel engines and pumps. Despite very little education, they have considerable talent as engineers. No doubt, the essential linkages at this stage of development were provided by the HYV package and the new technology, but the efforts of the local people in utilising the advantages offered by these linkages have been considerable.

To sum up, the transformation of Punjab agriculture has been the result of a continuous process. This was initiated as far back as British Colonization Period of the early nineteenth century and appears to have reached its culmination in the early seventies. In the pursuit of this achievement, various programmes and policies were adopted. Some met with limited success, some failed, while most were incorporated in the transformation process until the culmination was reached. Nevertheless, these programmes and policies provided some essential 'linkages' which were maintained and administered to give an 'efficient sequence' in continuing the acceleration of the process of agricultural development in Punjab. Yet the Punjabi farmer remains the driving force in steering and maintaining the speed of this process.

A PERSPECTIVE ON AGRICULTURAL DEVELOPMENT

Agricultural development is a process which involves a sequence of interrelated steps, in which each step is induced by the previous one and the present, in its turn, creates the conditions which enable a further step. To initiate the process of development in the developing countries, it is critically essential that the first move is the one which has the necessary element to spark it off. Therefore, a thorough knowledge of the local conditions becomes extremely important and, indeed, imperative. Geographic distributions tend to involve differences in the needs and responses of the people. Eastern Uttar Pradesh and Punjab have homogeneous geographic conditions, yet the differences in terms of people's attitudes, their aspirations, adaptations and receptiveness, and thrift to work have been found to be considerable: the former is still struggling with the initial problems of agricultural improvements, while the latter, presents the most dynamic agricultural system in the country.

Consider the case of irrigation water as an innovation as the first step. Canal irrigation was introduced in Andhra Pradesh at the early stages of development in spite of the complete ignorance and lack of receptivity of the local farmers. This was clearly a wrong step as is evidenced by Nair (1961: 69-70):

According to Yella Reddy, a peasant of another village, even the KC [Kurnool-Cudappa] canal area took fifty years to develop. "People gave up their rights on the lands and went away", he says, because they could not or did not know how to cultivate wet crops. Then others, mostly immigrants, applied for and obtained their lands. "Most of the present *ryots* are not the original owners. These lands are not their ancestral properties but were acquired in this manner".

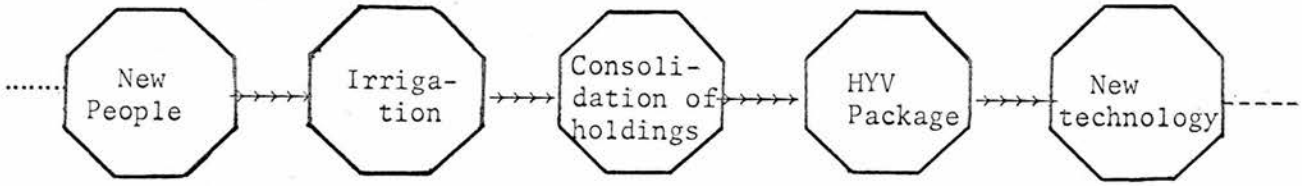
... however, many of the present cultivators are no more interested in having additional irrigation, although according to Yella Reddy, "even coolies are eating rice now". As in Raichur, they say they will take the canal water for "dry" crops only if the rains fail. They are not interested in increasing their yields by irrigating them even when it rains. As for paddy, which must be irrigated here, they claim to be satisfied with what they are getting from the KCC [Kurnool-Cudappa Canal] irrigated lands. They do not seem to be anxious to increase the area under rice cultivation because they say the cost of levelling of land is too high.

Yella Reddy himself is an old man, ... He is vice-president of the village *panchayat*. He owns 70 acres of land, of which only eight acres are wet at present. Now 40 more acres of his have become irrigable by the TBP [Tungabhadra Project]. But Yella Reddy has not taken a drop of its water.

Contrary to this, the efforts to promote and encourage irrigated farming was a welcome step in Punjab, partly because the refugee farmers, who had experience of irrigated farming, were eager to procure irrigation water. They provided leadership in irrigated farming, whose benefits were soon perceived by their local counterparts who, in turn, followed suit. Partly, also, the fact that the Punjabi farmer is relatively much more progressive and innovative-minded than his counterpart in other States of India. In fact, they voluntarily initiated the process of irrigated farming in many areas by installing their own tube-wells and pump-sets for assured and self-controlled irrigation. Some of them, sure of their success, moved to the new areas where canal irrigation was recently introduced. These were largely in canal-irrigated areas of the border States such as Haryana, Uttar Pradesh and Rajasthan. Their role in the transformation of agriculture of these States cannot be underestimated.

Once a change is successfully negotiated, others become relatively easy to introduce. But these change factors must provide essential linkages in the logical sequence of the process. It is little use having disconnected spurts in development process. The smoother the sequence, the more beneficial are the effects by yielding sustained results. The effectiveness of the sequence, moreover, largely determines the pace of the development process. Therefore it is not only difficult, but irrational too, to predict the time scale or to fix the pace for such a process. Much will depend on the capacities and capabilities of the people involved. The process of development is that perceived by the people as a rational and continuous concept, and not the chronological concept in sequential form viewed in the abstract.

The present study, particularly in elucidating the 'processes of change', supports the hypothesis that Punjab appears to have provided this 'efficient sequence' and, as a result, progress has been remarkable in all its dimensions. The essential linkages which provided a logical sequence to the process of agricultural development in Punjab are considered to be:



ESSENTIAL LINKAGES IN THE DEVELOPMENT PROCESS

The precursor to change may be difficult to determine in any particular situation or equally the current linkage seldom represents the ultimate in any situation. In Punjab, the incoming of new people has been a unique instance which emerged as an historical accident. These new people were largely responsible in breaking the existing structure of farming by introducing irrigated farming and other techniques which were largely new in the area. This one factor provided the spark to fire the process of agricultural development. Obviously, it may not be possible elsewhere. Therefore some other factor(s) may have to be introduced to break the 'vicious circle' of tradition and orthodoxy. Irrigation may be one such factor for it has the necessary complexity to generate change in multiple ways, giving the willing acceptance of the people. To create the will, agricultural extension in educating the people through demonstration husbandry, visits to the irrigated-farming regions, the establishment of irrigated farms amidst the farming community and so on may be considered essential to precede irrigation.

It may not be feasible, however, to transplant one 'efficient sequence' of a region to another in the same way or the same order. An example may provide some useful lessons for the structuring of 'efficient sequences' elsewhere. The order however will have to be different and may vary widely from region to region and from country to country dependent upon the geographical conditions, political ideologies, economic systems, social values and individual preferences. In the words of Hunter (1969: 281):

> Though many similar things will have to be done if the daily life of peasant societies is to be enriched and liberated, their path of change will be unique. It will not be exactly the same things which are done, nor in the same order, nor by the same methods, nor in the same modality.

Nevertheless, it is possible, though difficult, to construct a logical sequence after thorough study of the local ecological factors. This may be slow or may be fast but it will result in more stable patterns. The role of the local people will, no doubt, be crucial in structuring such a sequence and carrying it through.

IMPORTANCE OF DIFFUSION

The essential aspect of the process of agricultural development in Punjab has been the diffusion of new ideas, new farming techniques, new inputs and new technology. It should be noted that the adoption of any innovation is a process of learning, deciding and acting over a period of time. Therefore, the adoption is not the result of a single decision to act but a series of actions and thoughts. Generally, it follows various stages: (a) the awareness stage, (b) the interest stage, (c) the education stage, (d) the trial stage, and (e) the adoption stage. Some may move slowly through these stages while others may move more quickly or may even jump through some of these stages. This depends largely on the intrinsic values of the innovations in terms of their feasibility and their need, and partly on the receptivity of the farming communities. It is beyond the scope of the present study, to pursue a detailed investigation of the process of diffusion but it is possible to provide a simple structural model of agricultural innovation flows, and to investigate the major underlying strategies (intended and unintended) involved in the process. Nevertheless, this may form a very useful subject for a future study. The need for such studies is great for the subject has not been investigated in detail in India.

The decision to innovate is more complex than is generally perceived or acknowledged and is influenced by economic, political, social, cultural and personal factors. Actual decisions vary because farmers have different goals, different aspirations, different levels of knowledge, and vary in their aversion to risk and uncertainty. Nevertheless, some innovations are accepted more quickly than others. Kindleberger (1965: 149) has rightly stated that 'Innovation is most effective when it responds to emergent needs; imitation contributes the most, in its turn, when it is adaptive'. In Punjab, irrigation was the innovation which met the 'emergent needs' of the refugee farmers who had the presence and drive to accept it. Soon after, irrigation was adopted by others in the State and became, in fact, the essential pre-condition to most other innovations. It has been shown that the farmers with the possession of irrigated water innovate more quickly and have much higher rate of adoption than their counterparts who do not possess it (Chapter 16).

The acceptance and diffusion of innovations is without doubt, greatly influenced by their intrinsic merits and potential. But considerations such as the timely supply and the price structure of the inputs, reliability of water sources, ecological relevances, composition of farm labour, risk and uncertainty elements, profit margins, and farmers' resources, needs and obligations are in no way less important in influencing the decisions to innovate. Leaf (1972: 58-59) in his study of a Sikh village in Punjab has stated very effectively:

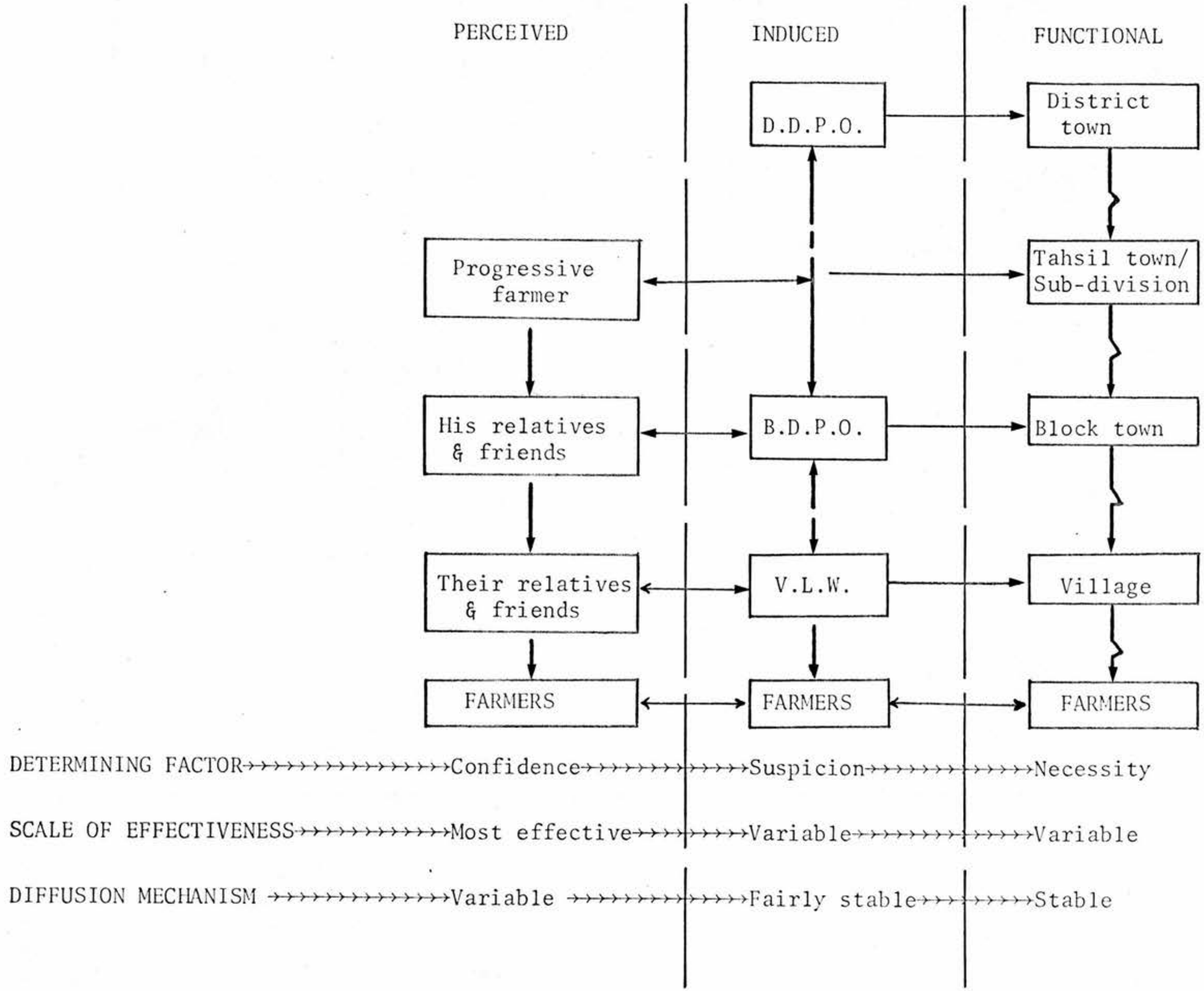
> Given the costs of failure, the strategy of most villagers in response to possible innovations is to wait and see, to let a few who can afford it bear the cost of establishing the necessary new information in the system through an experiment. Just one or a few farmers try first; then others follow. Failure to understand that villagers see themselves as part of an ecological system that provides a challenging array of possibilities, and yet is based on firm and inexorable laws of cause and effect, has led many Western observers to be surprised that in the adoption of new techniques the usual pattern is for the wealthier farmers to be more "progressive", and for the poorer, smaller farmers to be more "conservative" or "traditional". The truth is that the small farmers cannot afford the uncertainties of new unknowns, new manifestations of the sanctions hidden behind the complicated pattern of ecological objects, knowledge, and practices they use and respond to in gaining their livlihood.

The diffusion of agricultural innovations in Punjab occurs largely in three ways: (i) perceived, through progressive farmers, (ii) induced, through extension agencies, and (iii) functional, through urban hierarchy (Table 18.3). The pattern of diffusion is recognised as largely hierarchical in nature in all the three types (though diffusion processes do not always fit into a single category). It also has a time dimension. The whole process evolves in a well-structured sequence of events discussed earlier, although all or any of them may be operative simultaneously in a given situation. Some may be more dynamic than others. The assessment of such a complex mechanism of the diffusion process is difficult, yet a subjective but relative evaluation of each one of them is attempted.

Perceived hierarchy proceeds through the 'progressive' farmers who are innovators or early adopters. These farmers, because of their capacities to risk and increased resources, adopt the new practices first. Being an important part of the farming community, they interact with other farmers and communicate to them the information of a new practice. The immediate effect is generally on immediate neighbours who can see the benefits of the innovation or on those relatives and friends of the progressive farmer to whom he may be obliged to furnish the new information. After some time, more farmers acquire the information and adopt the practices. With the passage of time, the spread effect grows in its dimension, horizontally and vertically, and a large majority of the farmers adopt the new practice. These may be called late majority adopters. At this stage only the resisters to innovation are left.

Progressive farmers are generally in the best position to promote change in rural societies. The demonstration effect of a new practice and the confidence in a member of the community play a crucial part in the

TABLE 18.3 A GENERAL MODEL OF DIFFUSION OF AGRICULTURAL INNOVATIONS IN PUNJAB



acceptance of the new practices. Moreover, these farmers are also associated with the formal and informal organisations and are usually leaders in the village community. The extension agencies concentrate more on the progressive farmers because it makes their work easier and more comfortable.

Induced hierarchy diffuses through organised and planned structures. The extension agencies are designed to disseminate information and render other services to the farmers. Because it follows official channels, its flow is generally less smooth. The extension staff are often overloaded with multifarious duties and official book-keeping; they tend to spend more time at district headquarters in attending various meetings and writing reports than they spend with the farmers. The element of suspicion further reduces the effectiveness of the extension services. Yet much depends on the sense of dedication and industry on the part of the extension staff. Some may be more dynamic and effective than others. The extension agencies undoubtedly, influence all stages of the adoption process, but they are largely less effective and efficient than perceived experience.

The functional hierarchy is urban based as the movement of inputs and outputs must flow through the service system from big to lesser town. These flows generally have irregular patterns both in time and space, partly because of administrative snags, black marketing and other related corrupt practices, and partly, because of shortages of farm inputs. Firms selling farm implements, machinery, pesticides, fertilizers, and seeds are mainly concentrated in the urban areas, and while they form an additional source of agricultural information, they have no committed intent to disseminate ideas. They operate in a sellers' market and therefore do not extend their knowledge to the majority of the farmers. However, the source is useful to innovators and early adopters (progressive farmers) who seek information on their own accord.

On the whole, diffusion of innovations is most effective through perceived benefits, less through organised and planned extension and least through functional urban hierarchy in terms of neighbourhood effect. Three factors must be distinguished in the pattern of adoption of innovations: firstly, the adoption is highly linked with irrigated water; secondly, it must respond to the immediate needs of the farmers; thirdly, it should be out-put raising and factor-saving. If it is factor-using, the profit margins must be kept high. This is true even for out-put raising technologies. 'In sum, to determine what are the influences on innovation acceptances is a far more hydra-headed problem, beset by far more intricate, interacting forces than is often acknowledged' (Harriss, 1972: 87).

IMPLICATIONS: SYSTEM STABILITY AND CHANGE

Prior to Independence in 1947, the Indian Punjab, as the rest of India, was largely a region of self-sustained villages in which traditional agriculture, based on centuries of experience, was more a way of life than a business. The changes in Punjab agriculture, both qualitative and quantitative, which occurred thereafter had been very rapid indeed. In consequence a modified and improved physical, social, economic and political environment has emerged and Punjab has been transformed from a backward agricultural economy to one of the most progressive and dynamic economies in the country.

These developments have been responsibe for massive spurts in agricultural production which have led to the belief that the country is able to feed itself. Nevertheless, there are several important implications - social, economic and political - which must be noted. First , this miraculous transformation has occurred only in a few areas or States where irrigation water was available or made available. Therefore, it has had little impact on three-fourths of the national cropland which remains largely rainfed. Secondly, there are large variations in achievements, not only inter-State but intra-State or even within the districts of a State, because the prosperity generated by the system (new technology) has not been evenly distributed. Thirdly, even in areas of assured water supplies, it did not favour the poor, small farmers and agricultural labourers. The new technology is basically a high-cost high-yield technology which demands high capital investments beyond the means of small farmers, who form a majority of the farming community (rather total population) throughout the country. Fourthly, despite the efforts of the government (conscious or otherwise) to reduce the gap between rich and poor, and to help make the small and marginal farmer an effective vector of economic progress, one obvious implication is that a substantial part of his profit (if any) will be siphoned off in debt repayments. The small size of his holding in a high-input and expensive farm technology is serious enough a limitation. Fifthly, the long-run effects of farm mechanisation and automation reducing farm employment in a labour-surplus situation are inevitable and the continuing trends may lead to massive unemployment. This factor must also take cognizance of the fast increasing national population.

Consequently, the already existing income and wealth gaps are widening. Socially and economically, the poor and the weak remain isolated from the rich, strong and dominant elements in the village milieu. The odds against the poor are heavy. They do not and perhaps cannot feel and form a part and parcel of the prosperity. 'Conversely, in the midst of prosperity, they feel aggrieved, cheated and deprived' (Roy, 1972: 42). Therefore, this remains the most crucial argument of all arguments. In the words of Thapar (1972: 38) 'As long as the rural scene was one of uniform stagnation, dissatisfaction merely simmered; but now that is no longer the case it is potentially explosive'.

The dynamics of the emerging patterns are largely high-input based and dependent on power-operated implements. Water development remains critical to any development strategy, but equally important is the availability of energy, fertilizers and pesticides. With increasing awareness of the economic benefits to be derived from their use coupled with the incentives provided by the government in favour of new farm technology, the demand for these inputs is likely to expand considerably. General shortages, nationally and internationally, temporary or prolonged, of fuels and other essential inputs such as fertilizers will affect considerably the future course of these developments. Inflation will also have serious repercussions in a capital-scarce situation. Yet, the present observed trends of the changing agricultural patterns will inevitably continue, although it is difficult to forecast the ultimate sequence. Future government policies will, however, remain crucial in establishing priorities, while the will and skill of the farmers will undoubtedly influence the reshaping and reordering of future developments.

The stability of the system is dependent on both external and internal forces. External forces operate through both technological requirements and economic aid which is essential (at least it is thought so) to development programmes. Internal pressures involve social, economic and political factors. The state of the national economy has a serious impact on the development of urgently needed infra-structure and irrigation water resources as well as on procuring chemical fertilizers, all of which are essential to expand the agricultural economy. Socially, the inequality of incomes and opportunities aggravated by the increasing numbers which are swelling the ranks of under-employed and unemployed in the country may lead to a fluid political situation. In fact, the signs of tensions have already started appearing and are mounting rapidly. However, those who have once tasted prosperity are not amenable to reason or persuasion. Rich farmers, because of their social status, education and relative affluence, effectively control all the levers of power, socially, economically and politically. 'The government seem to be caught in the dilemma of compulsion to change and opposition to change - so powerfully mounted by the landlord's lobby' (Roy, 1972: 42). Prosperity, to the exclusion of social imperatives, creates an unsettled and unpredictable political situation. At present, the vulnerability of the system appears to be high and is largely subject both to exterior causes and forces beyond national control, and to internal pressures which may not be containable.

VERIFICATION OF THE HYPOTHESIS

This study set out to validate three hypotheses, in an area with both established and new agricultural lands. Bist Doab also includes hilly tracts and waterlogged areas, which have their own specific problems, and therefore characterises large areas of Punjab, or for that matter, of northern India.

The following conclusions have wide application:

1 Agricultural development in the developing countries is not a matter of abrupt transformation. The present study supports the view that agricultural development is a continuous process of evolving patterns whose roots can be traced back in an historical context. In any one area, physical conditions and cultural milieu may enhance or retard the speed, and determine the path, of the process of development. Certain stimulating elements can be planned and induced, but the receptivity of the farming community remains a critical factor in any change.

2 The physical environment provides a suitable crop growing milieu in Bist Doab, but there is a strict limitation imposed by precipitation which is variable in time, amount and space. The need, therefore, for a self-controlled and assured supply of irrigated water in high-inputs farm technology is essential. In Bist Doab, or for that matter in Punjab, water is the single most important catalytic factor in the transformation of agriculture. Water resource development will remain critical to any future strategy of agricultural development in Punjab, as in the rest of India.

3 The key factor in agricultural development and change however, is the human element. Punjab farmers present a coherent group of receptive, open-minded, hard-working and instinctive husbandmen. They have good partners in the '<u>Ramgarhias</u>' who provide machine tools and farm implements and in Hindu entrepreneurs who provide effective

systems of trade, marketing and allied services. Without the presence of a dynamic element in the farming population, there can be only limited success in any form of agricultural development. The words of Nair (1969: ix) sum it up:

> Of all the variables in agriculture ... the farmer is the most crucial and the least predictable. He plows a lonely furrow. It can be deep or shallow. Accordingly ... the richest soil can yield poorly, and vice versa, depending on the will and skill of the cultivator.

APPENDIX I GLOSSARY OF TERMS

AGRICULTURAL TERMS USED

Agricultural land (Cultivated area) The area which is currently under plough and it includes both net area sown and current fallow. As the livestock is not developed to the extent that it could take an independent land use category, the land under cultivation is in fact taken as agricultural land or cropland.

Cash crops Include oilseeds, sugarcane and cotton.

Crop failure A crop which either fails to germinate or dries up or is destroyed due to lack or excess of moisture, rust diseases or any other natural hazard, is taken as crop failure.

Crop pattern Proportion of area under different crops at a point in time.

Cropland see Agricultural land.

Cropped area Includes actual area sown and area sown more than once in the current year.

Cultivated area see Agricultural land

Current fallow Includes land which remains unsown for up to two harvests (one agricultural year) either to regain fertility or due to lack or excess of moisture or on account of other social and/or economic reasons.

Forests Include areas which are administered as forests, whether State owned or private. Any land which is cultivated within the forests is not included under the category of forests. It does not include forests along the sides of roads, railway lines, canals and other drainage and irrigation channels.

Extent of cultivation Implies cultivated area as a percentage of total area.

Extent of irrigation Implies net irrigated area as a percentage of net sown area.

Harvested area Is the area in which the crop has actually matured or harvested during the crop season/seasons. Indeed, it is the total cropped area less area of crop failure.

Intensity of cropping Implies cropped area as a percentage of net sown area. For example, if one crop is raised in a field in a year, the intensity would be 100; if two crops, the intensity would be 200.

Intensity of cultivation Implies net sown area as a percentage of cultivated area.

Intensity of irrigation Implies total cropped area irrigated (kharif and rabi) as a percentage of net sown area.

Kharif cropping Summer cropping, July to September-October.

Land available for cultivation Comprises the land which can be cultivated, according to the present standards of cultivation, but is not cultivated for various reasons. It also includes pastures and other grazing lands (village common land is also included), land under miscellaneous tree crops and groves, not included in net sown area. The land which has not been sown for four successive harvests (two agricultural years) also forms a part of this category. This category is generally termed as 'Cultivable waste' and can be taken as 'potential agricultural land' and has been referred as such in the text.

Land not available for cultivation   It comprises land put to non-agricultural uses such as land under roads, railway lines, canals, buildings, barren and uncultivable land such as river beds and bare rocky outcrops. It is non-agricultural.

Multiple cropping   A practice of producing more than one crop on a plot of land within one year.

Net sown area   Is the area on which sowing is actually done during the course of the year. It may be termed as net cropped area.

Non-agricultural land   see Land not available for cultivation.

Potential agricultural land   see Land available for cultivation

Rabi cropping   Winter cropping, October to March-April.

Uninhabited village   A village without any permanent settlement.

Zaid Rabi   Mid-summer cropping.

COMMON AND BOTANICAL/ENGLISH NAMES OF CROPS

Alsi: Linum usitatissimum

Alu: Solanum tuberosum - Potato

Arind: Ricinus communis

Bajra: Pennisetum typhoideum - Bulrush or spiked millet

Band Gobhi: Brassica oleracea - Cabbage

Berseem: Trifolium alexandrinum - Egyptian clover, a fodder crop

Bhindi: Okra - Lady's finger

Cheena: Panicum miliaceum

Gandh Gobhi: Brassica oleracea - Knol khol

Gajar: Daucus carota - carrot

Ghia Kaddu: Bottle gourd

Guara: Cluster bean

Halwa Kaddu: Red gourd

Japani Sarson: Brassica napus

Jau: Hordeum vulgare - Barley

Jhona: Coarse variety of rice

Jowar: Andropogan sorghum - Millet

Kali Tori: Sponge gourd

Karela: Bitter gourd

Kharbuza: Musk melon

Khira: Cucumber

Lassan: Allium sativum - Garlic

Lusan: Medicago sativa - lucerne.

Mash: Phaseolus radiatus

Massars: Lens esculenta

Matar: Pisum sativum

Metha: Trigonella foenum-graceum - Fenugreek, a fodder crop

Moong: Phaseolus mungo

Moth: Phaseolus aconitifolius

Muli: Raphanus sativus - Radish

Mundawa: Eleusina coracana

Mung: Phaseolus mungo

Palak: Beta Bengalensis

Petha: Ash gourd

Phul Gobhi: Brassica oleracea - Cauliflower

Rai: Brassica juncea

Salad: Lactuca sativa - Lettuce

Salhari: Apium greveolens - Celery

San: hemp

Sankukra: hemp

Sarson: Brassica campestris var. glauca

Senji: Melilotus parviflora - Indian clover

Shaftal: Trifolium resupinatum - Persian clover

Shakar-Kandi: Sweet potato

Shalgam: Brassica rape - Turnip

Swank: Panicum colonum

Taramira: Eruca sativa - Rocket

Tarbuz: Water melon

Tinda: Citrullus vulgaris var. fistulosus

Toria: Indian rape

Wadanak: Triticum durum - Macaroni wheat

PANJABI/HINDI WORDS

Abadi: Village settlement.

Banias: Of Vaisya caste; engages primarily in business. The word is also used to describe a grocery shop-keeper.

Bar: An arid tract.

Basmati: A fine variety of rice.

Batai: Share cropping.

Bein: A small seasonal stream.

Bet: Riverain tract

Bhusa/Bhussa: Straw crushed and broken into short lengths by trampling with bullocks during the process of threshing.

Bist Doab: Meaning the land between two rivers, Sutlej and Beas. The word Bist was made by combining the first two letters of the names of each of the rivers - Beas (old spelling Bias) and Sutlej (old spelling Stluj). Doab is an Urdu word which means two (do) waters or rivers (ab).

Brahmins: A man of the priestly (highest) division of Hinduism.

Bund/Dhussi Bund: An earth ridge.

Coolies: A native labourer.

Chapatis: A thin unleavened cake prepared from wheat flour.

Chhambs/Chhumbs: A low-lying area, generally flooded during the rainy season.

Chhatta: Method of sowing by broadcasting the seed.

Choes: A fast flowing rainy torrent.

Dal: Split pulse with or without husk.

Dandal: A pegged sohaga (see Sohaga).

Darrar: Land rendered unfit for cultivation by deep gully erosion.

Desi: Indigenous.

Dhussi Bund: see Bund.

Doab: A land between two rivers (see Bist Doab).

Ghee: Clarified butter.

Gur: Raw sugar in lumps.

Hadbast: A village serial number assigned by the State Revenue Department.

Haryanavi: A native of Haryana.

Jaman Bandi: Cultivator's register.

Jhil(s): Natural lake(s).

Kaddoo: Puddling the field to make the mire fine.

Kallar: Also Reh or Usar: alkaline incrustation on soil.

Kanker: Calcareous nodules.

Kanugo: A revenue officer supervising the work of patwaris (see Patwari).

Kera: A method of sowing in which seed is dropped by a separate man behind the plough.

Khadar: Low-lying tract near a river. Soil consists of new alluvium.

Khad(s): Hilly torrent(s).

Kharif: A summer crop.

Khasra number: Serial number of a field.

Khurpa: A hand-hoe.

Lalkitab(s): Revenue inventory book(s).

Loo: A hot wind

Marla: 1/160 of an acre.

Maunds: Weight measure equivalent to 82.28 lbs.

Nadi: A small stream.

Nahr/Nehr: A canal.

Nallas: A small stream.

Palmal: A fine variety of rice.

Panchayat/Punchayat: A village council.

Panjabi/Punjabi: A native of Punjab.

Patwari: A village accountant or record-keeper.

Phala: A hurdle dragged by bullocks in wheat-threshing.

Pora: Sowing with the Por. In pora method of sowing the same man controls the plough and drops the seed.

Quintal(s): Unit of weight, 100 kilograms.

Rabi: A winter crop.

Ramgarhias: Carpenters and blacksmiths.

Ryot(s): Peasant(s).

Ryotwari: A system of peasant proprietorship.

Sag: Fried and boiled greens, generally mustard.

Samiti: A council.

Sarpanch/Surpanch: Head of a village panchayat.

Seer: 1/40th. of a maund, approximately = 2lbs.

Sem: Waterlogging.

Shajra: Field plan of a village drawn on a piece of muslin cloth.

Shamlat: Village common land.

Sohaga: Wooden beam worked by two pairs of bullocks, used for breaking clods and covering seed.

Thur: Land where salt content is high but the process of alkalisation has not proceeded very far.

Zaid Rabi: Crops of the season midway between Kharif and Rabi, autumn crops.

Zila Parishad: District Board.

APPENDIX II LABOUR REQUIREMENTS OF CROPS PER ACRE IN PUNJAB

Crop		Human labour (man-days)
Wheat	irrigated	37.9
	unirrigated	20.5
Wheat/gram	irrigated	30.0
	unirrigated	19.0
Gram (chick-pea)	irrigated	17.2
	unirrigated	10.8
Maize	irrigated	42.6
	unirrigated	38.1
Rice (paddy)	irrigated	51.2
	unirrigated	30.7
Jowar & Bajra (millets)	unirrigated	19.0
Pulses	unirrigated	4.5
Kharif fodders	irrigated	10.3
	unirrigated	3.6
Rabi fodders	irrigated	23.4
	unirrigated	4.5
Sugarcane (for canes)	irrigated	63.5
	unirrigated	41.2
Cotton (desi)	irrigated	52.6
	unirrigated	35.0
American cotton	irrigated	45.9
Oilseeds	unirrigated	5.5
Vegetables & potatoes	irrigated	75.0
	unirrigated	60.0
Orchards	irrigated	50.0

Source: Punjab, Board of Economic Enquiry, Pub. No. 77, 1961, p. 127

APPENDIX III CROP-COMBINATIONS DERIVED AFTER WEAVER (1954)

Monoculture

1. Wheat
2. Wheat/gram
3. Oilseeds

Two crop-combination

4. Wheat and fodder
5. Wheat and maize
6. Wheat and rice
7. Wheat and vegetables
8. Wheat and wheat/gram
9. Wheat/gram and gram
10. Wheat/gram and maize
11. Rice and fodder
12. Oilseeds and wheat
13. Oilseeds and wheat/gram

Three crop-combination

14. Wheat, fodder and maize
15. Wheat, fodder and sugarcane
16. Wheat, fodder and wheat/gram
17. Wheat, maize and rice
18. Wheat, maize and wheat/gram
19. Wheat, rice and fodder
20. Wheat, wheat/gram and vegetables
21. Wheat/gram, fodder and maize
22. Wheat/gram, wheat and gram
23. Rice, maize and fodder
24. Rice, maize and sugarcane
25. Rice, wheat/gram and wheat
26. Oilseeds, fodder and wheat
27. Oilseeds, wheat and rice
28. Oilseeds, wheat/gram and fodder
29. Oilseeds, wheat/gram and wheat
30. Vegetables, fodder and wheat

Four crop-combination

31. Wheat, fodder, maize and cotton
32. Wheat, fodder, maize and rice
33. Wheat, fodder, maize and sugarcane
34. Wheat, fodder, maize and wheat/gram
35. Wheat, fodder, oilseeds and maize
36. Wheat, fodder, rice and oilseeds
37. Wheat, fodder, wheat/gram and rice
38. Wheat, wheat/gram, fodder and oilseeds
39. Maize, fodder, rice and cotton
40. Maize, fodder, wheat/gram and gram
41. Maize, wheat/gram, wheat and rice
42. Maize, wheat/gram, fodder and oilseeds
43. Wheat/gram, maize, fodder and sugarcane
44. Rice, maize, fodder and wheat/gram
45. Rice, wheat, fodder and wheat/gram

Five crop-combination

46. Wheat, fodder, maize, oilseeds and cotton
47. Wheat, fodder, maize, rice and wheat/gram
48. Wheat, fodder, maize, wheat/gram and oilseeds
49. Wheat, fodder, maize, wheat/gram and sugarcane
50. Wheat, fodder, maize, wheat/gram and gram
51. Wheat, oilseeds, fodder, wheat/gram and rice
52. Wheat, fodder, rice, maize and sugarcane
53. Maize, fodder, wheat, wheat/gram and vegetables
54. Fodder, wheat, maize, vegetables and rice
55. Wheat/gram, rice, fodder, maize and sugarcane

Six crop-combination

56. Wheat, fodder, maize, sugarcane, wheat/gram and rice
57. Wheat, fodder, oilseeds, wheat/gram, maize and cotton
58. Fodder, wheat/gram, maize, wheat, sugarcane and gram

Seven crop-combination

59. Fodder, wheat/gram, maize, wheat, gram, pulses and oilseeds

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